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JAPAN

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[Text] **Section 1. Toward the Internationalization of Japan's Science and Technology**

Introduction: Overview of Japan's Science and Technology

In Japan, the funds used for science and technology research amounted to ¥8.1 trillion in FY 1987, 3.19 percent of the country's gross national product. If the funds used for research in cultural and social sciences are added to this amount to obtain a figure that can be used as a comparison internationally, the total amount becomes 3.49 percent of the gross national product and the researchers number 406,000.

The above figures give a view of the state of science and technology in contemporary Japan. The statistics, on which these figures are based, are gathered in different ways in different countries and their contents vary between countries. Therefore, directly comparing the figures statistically obtained in different countries is not suitable for accurate analysis. When the figures on Japan are compared with the corresponding figures on other countries just to obtain general reference information, Japan is ranked second next to the United States in the free world with respect to the total amount of research expenditures and the total number of researchers. It is first in the free world in terms of the ratio of the total amount of science and technology research expenditures, including funds used for research in cultural and social sciences, to its gross national product.

In FY 1955, about ¥40 billion was used in Japan for science and technological research. This is about 13 percent of the corresponding figure recorded in Britain and about 0.84 percent of Japan's gross national product of the same fiscal year. With respect to both the total amount of research funds and its ratio to the gross national product, Japan ranked lowest among the five major industrial countries, the United States, Germany, France, Britain, and Japan itself. Recalling the first-mentioned figures on Japan for FY 1987 in light of the 30-year old figures, one may feel as if in a different age.

Even before looking back at the last 30 years, it can be said that science and technology has played an extremely important role in Japan--a country which, lacking natural resources, cannot but depend on its intellectual creativity for its survival--in the course of its modernization after the Meiji Restoration and rehabilitation after World War II. Today, Japan's science and technology may be said to have reached the world's top level in some areas centering on industrial technologies. Before reaching where it is today in terms of science and technology, Japan positively introduced superior science, technologies, and culture from advanced Western countries, modified them and made painstaking efforts at applying them to practical use. Its science and technology having progressed very rapidly as described above, Japan has now entered an era in which it should promote its own unique science and technology while fulfilling its international duties as one of the world's advanced countries and maintaining its competitive and collaborative relationships with other countries.

It will be important to first review the course through which Japan's science and technology has developed, the level it has reached, and the problems it now faces.

From the above point of view, the development to date and recent trends will be discussed in this introductory section.

- **Historical Development of Japan's Science and Technology**

Through the years before and after World War II, Japan has stressed education based on the realization that the prosperity of the country which lacks natural resources is dependent on science and technology. While nurturing quality in human resources, Japan has promoted its science and technology by learning from advanced countries, modifying, in a unique way, technologies introduced from overseas and making great efforts to put the technologies to practical use.

Particularly, after World War II that devastated the country, Japan's science and technology rapidly developed, centering on industrial technologies. The researchers and technicians brought up with a high level of education in the prewar days worked as a core driving force for the postwar development of science and technology. Therefore, it must not be overlooked that the country's scientific and technological assets, centering on human resources, accumulated to a considerable degree before the war and greatly contributed to the postwar rehabilitation of the country.

This section will present an overview of the postwar progress of Japan's science and technology to understand the present status of Japan's science and technology.

<1945-1954>

In the early 20's of the Showa era [1945-1954], Japan was in a chaotic situation socially and economically in the aftermath of World War II.

During that period, Japan reformed old systems and created new ones to promote scientific and technological activities.

Let us review the establishment during that period of systems for the promotion of scientific and technological activities. In 1947, a scientific activity system reformation committee was set up as an advisory organ for the prime minister for the purpose of promoting the reform of systems for scientific activities. In 1949, on the basis of a report submitted by the committee, the Science Council of Japan was inaugurated with the consensus of the scientists. The Council's purpose was to contribute toward the peaceful rehabilitation of Japan and the promotion of the welfare of the whole world and to facilitate the progress of science in association with the academic societies of other countries. In the same year, the Scientific and Technical Administration Commission was inaugurated in the Prime Minister's Office with the aim of seeking measures, in close cooperation with the Science Council of Japan, to ensure that science and technology was reflected in the administration. Furthermore, it was decided to continue, as an organization for the promotion of science, the Japan Society for the Promotion of Science established in 1932. National and public research institutes were also reorganized. For example, the National Institute of Health was established in 1947 and the Agency of Industrial Science and Technology in 1948. In 1949, universities, organized under a new system, were inaugurated.

During the same period, efforts were also made to raise the standard of Japan's science and technology, which had fallen below that of other countries due to the war, to an international level by positively introducing the science and technology of advanced countries. However, Japan was short of foreign exchange at that time and enterprises experienced difficulty in securing, on a stable basis, foreign exchange to pay for technologies purchased from foreign companies. In 1950, the foreign exchange law was established to ensure the availability of foreign exchange to be remitted for technologies purchased from overseas. As a result, it became easier for Japanese enterprises to positively introduce foreign technologies.

What was the above period like when reviewed from the aspect of industrial technologies? The Japanese munitions market collapsed in 1945. As a result, the machine industry in particular was obliged to start manufacturing durable consumer goods. Under these circumstances, the government established the offset price substitute system in 1947 in order to help enterprises lacking competitiveness on the international market. The system was, however, abolished in 1949 because of the Dodge line. Subsequently, the Japanese enterprises were obliged to enhance their competitive power through rational management.

In 1950, the Korean war broke out, causing a munitions boom in Japan and the difference in price between the Japanese and foreign products to rapidly narrow. Subsequently, the Japanese enterprises weathered the difficult stage onto which they had been thrown immediately after World War II and proceeded to the development stage during the 30's of the Showa era [1955-1964].

In that transition period, capital accumulation grew larger and production control systems were more widely disseminated.

It is also worth mentioning that Hideki Yukawa, then professor at Kyoto University, became the first Japanese to win a Nobel Prize in 1949 when Japan was still in its rehabilitation stage. He was awarded the Nobel Prize in physics for his research work disclosed in 1934. This may indicate that the steady efforts continued by Japanese researchers from before the war finally started to gain international recognition around that time.

<1955-1964>

In 1955-1964 the importance of original technology development started to gain recognition in Japan which had previously heavily depended on technologies introduced from abroad. During that period, the reformation of systems, including administrative ones, for the promotion of science and technology progressed a great deal. In fact, most of the existing systems for the promotion of science and technology came into existence during that period.

Reviewing these system reformations, in 1956 the Atomic Energy Commission was created, the Science and Technology Agency was established as a government office to integrate and promote the administration of science and technology, and the Agriculture and Fishery Technology Council was inaugurated in the Ministry of Agriculture, Forestry and Fisheries. Then, in 1957, the Japan Science and Technology Information Center was established. In 1959, the Institute of Physical and Chemical Research was converted into a special corporation. The Science and Technology Council was also set up in the same year as an organ to advise the prime minister regarding science and technology-related policies. The council submitted its first report titled "Basic Policy for the Promotion of Science and Technology Integrated With an Eye on the Future 10 Years Hence" in 1960 in response to the income-doubling program launched by the Cabinet earlier the same year. This report suggested a basic policy for substantially augmenting the human resources and enhancing the research and development activities in the field of science and technology with the aim of achieving high economic growth rates in the 1960's and catching up with the advanced countries in Europe and America with respect to science and technology. During this period, the idea stressing the necessity of promoting original technologies, that had started in 1945-1954, gained momentum and it was considered necessary for Japan to catch up with advanced countries in technology and proceed to develop original technologies on its own. The subtitle "Out From Dependence on Foreign Technologies to Independent Development" of the 1958 white paper reflects the above trend of that period. Under the circumstances, the Research Development Corporation of Japan was established in 1961. It is aimed at strongly promoting the development of domestic technologies. Its duties include assigning the development of new technologies to private enterprises and providing its good offices for technology development between different parties.

The importance of carrying out technological innovation was also recognized in the private sector during the same period. Subsequently, a central laboratory construction boom occurred among the private enterprises. The boom peaked in 1961.

What was this period like from the aspect of industrial technologies? In the international wave of high economic growth that started in 1955, a wave of prosperity dubbed "Jinmu keiki" occurred in Japan. During the boom, durable consumer goods came into heavy demand. Not only the consumer durable goods industry but the enterprises in other industries enjoyed continuous thriving business and achieved major development. The technical standards of the shipbuilding and camera industries in particular were greatly improved and in 1956 Japan ranked top in the world on tonnage of launched ships. Research in the development of civilian applications of transistors was also positively conducted. In 1955, transistor radios were developed in Japan. Subsequently, transistors found more and more applications such as in electric washing machines, refrigerators, and TV sets. The Japanese motorcycle industry also attained a rather high level of production techniques during that period. The demand for nylon sharply increased and in 1964 Japan became the world's top exporter of synthetic fibers.

In the latter half of the 30's of the Showa era, 1960-1964, the development of the Japanese steel industry was remarkable. Many kinds of state-of-the-art equipment including LD converters were installed pushing Japan up to the world's top level in steel production techniques.

<1965-1974>

In the 40's of the Showa era [1965-1974], many large-scale projects were launched in the field of science and technology while the policy of promoting independent technological development adopted in the 30's was also maintained. The projects launched include those for atomic energy utilization and space development. In the latter half of that decade, Japan came to face environmental problems, pollution being typical, which were growing more and more severe in keeping pace with the rapid expansion of economic activities in the country. As a result, the necessity of assessing the applications of science and technology from the standpoint of environmental protection were pointed out. Furthermore, during 1970-1974 Japan experienced violent changes in the situation worldwide such as the Arab oil embargo and the tightening of demand-supply relations in the food market. It began to recognize the importance of science and technology development in keeping up with an age of great changes.

Research expenses in Japan totaled about ¥430 billion for FY 1965, 1.61 percent of the gross national product recorded in the same fiscal year. These figures were lower than the corresponding figures recorded in the advanced countries in Europe and America. However, total research funds were about 10.6 times larger than that of 10 years before, so that the rate of growth of research funds was already much higher than that of the advanced countries in Europe and America.

The high growth in research investment was largely attributable to the private enterprises oriented toward independent technological development. For its part, the government also attempted to see that more money was invested in research and development. While increasing the amount of R&D funds appropriated from the national budget, it created a system for tax credits for increases in experimental and research expenses in 1967 in order to encourage the private enterprises to conduct more research and development work. To financially support the private enterprises engaged in R&D work, the government adopted in 1968 a finance system to be managed by the Japan Development Bank for the promotion of technological development.

So-called major technologies in such fields as nuclear power development, space development, and marine development also started development toward full-fledged evolution during this period. A number of national projects aimed at promoting the development of domestic technologies were inaugurated and promoted through joint efforts by the public and private sectors. In the field of nuclear power development, for example, the Atomic Energy Commission decided in 1966 on domestically developing a fast breeder and a new type of converter. Then, the following year, the Power Reactor and Nuclear Fuel Development Corporation was established as the coordinator of the plans for breeder and converter development. In the field of space development, the Space Development Commission was created to replace the old Space Development Council in 1968. The following year, the National Space Development Agency was inaugurated to promote the full-scale development of artificial satellites and booster rockets.

The rapid development of the Japanese economy during 1965-1974 brought about pollution in some areas, causing health- and environment-related problems to become noticeable in society. As a result, the science and technologies that can be used to solve such social problems started to draw attention. In light of this situation, the Science and Technology Council submitted its report No 5 in 1971. The report discussed the necessity of technology assessment and suggested a policy direction based on a new motif with stress on the promotion of life sciences and soft sciences.

From the viewpoint of industrial technologies, it can be said that the Japanese automobile industry made rapid technological progress during 1965-1969. This progress resulted in sharp increases in demand in general, for example, for road construction, building, bridge construction, and steel materials, eventually leading to an exceptionally high rate of growth in the Japanese economy.

In 1970-1974 the initial growth in demand for consumer durables such as cars and TVs ran its course in the domestic market and a move to seek fresh markets outside the country quickly intensified. At the same time, it became necessary for the industry to market a larger variety of products to meet diversified needs of customers seeking upgraded versions of the products they initially purchased. Eventually, against a backdrop of rapid advances in the development of NC machines, automated lines for limited production of different types of products were swiftly disseminated among the manufacturers of consumer durables.

The overall balance of payments of Japan's technology trade with foreign countries is still in the red by a large margin. However, this balance of payments based on additional contracts turned black in 1972 and has stayed in the black since then.

<1975 to present>

In the period up to 1975, stress regrading the policies for the development of science and technology was put on the development of technologies with practical prospects, research work which was already in a final stage, and, therefore, the successful development of which was highly likely. In the subsequent period extending to the present, fundamental research to create technological seeds has gained importance. In the beginning of this period following the oil embargo, how to secure a stable energy supply became a major task to be tackled.

In FY 1975, the research funds used in Japan totaled about ¥2.62 trillion, 2.11 percent of the gross national product of the same fiscal year. The total amount of research funds exceeded the corresponding figure recorded in France and Britain for the same fiscal year. Thus, Japan joined the top group of countries on a statistical basis, even though, as previously mentioned, accurate analysis cannot be made by directly comparing the statistical figures gathered in different ways.

With regard to science and technology-related policies, the Science and Technology Council submitted its No 6 report in 1977. The report pointed out the necessity of carrying out policy measures aimed at enhancing the nation's ability to cope with drastic change in the international circumstances, for example, those triggered by the oil embargo by Arab nations, while giving consideration to the quality of medical care for its people and their welfare. The report, submitted when securing a stable energy supply was a major target, stressed the importance of developing energy sources that can be used instead of oil.

As the scientific and technological standard of Japan rose year by year, the country came to increasingly recognize that it was in a period of transition from a stage where it had to learn mostly from other countries to a stage where it would have to develop more new technologies on its own. Reflecting this trend, the science and technology-related policies adopted around that time attached increasingly great importance to fundamental research. In the 1981 and 1983 white papers, the importance of the creative development of original technologies was discussed as their themes. The Science and Technology Council submitted its No 11 report in 1984, basically calling for 1) the promotion of highly creative science and technology; 2) the development of science and technology harmonized with human beings and society; and 3) the evolution of science and technology with importance attached to internationality. The report outlined the basic policy to be adopted for the subsequent 10 years to promote the coordinated development of science and technology to lay the foundation for new culture and civilization with an eye on the

21st century. Based on this report, the Cabinet formed an outline of policy measures for the promotion of science and technology in 1986.

Regarding industrial technologies, Japan has reached the world's top level in such fields as steel, automobiles, and home electric appliances during this period. Today, Japan with its high standard of technologies is in a position where it can greatly contribute toward the development of technologies, mainly in high-technology areas, on a global basis.

With Japan where it is now, great expectation is placed on it as a leading country in the field of science and technology. At the same time, the rapid growth in the exports of Japanese products supported by the superior industrial technologies of the country have been causing trade frictions in various parts of the world. In the situation where its relations with other countries appear to grow tenser, Japan is required to decide on the course of its future actions by recognizing the international duties and roles commensurate with its abilities in science and technology.

Recent Trend of Japan's Science and Technology

Japan has reached the present high level in science and technology through the above described developments.

In this section, the recent trend of Japan's science and technology will be discussed from the policy-related aspects and also from the viewpoint of research activities by the government's research institutes, universities, and private enterprises.

Features of R&D Conducted in Japan

Before discussing the recent trend of Japan's science and technology, let us first consider the features of R&D activities conducted in Japan in comparison with those conducted in other countries. Even though accurate analysis cannot be made by directly comparing statistical figures gathered in different ways, the features of Japan's R&D activities can be summarized as follows based on statistics:

First, the promotion of science and technology is centered on civil technologies.

Second, the R&D expenses spent by private enterprises account for a considerably high proportion of the total R&D funds used in the country. In FY 1985, for example, the proportion stood at 80.5 percent.

Third, the cross-flow of research funds (the flow of research funds between different organizations) is small and the organizations which bear research expenses and the parties which conduct research are, in many cases, closely related.

Fourth, while Japan's industrial technologies are at very high levels, the country is said to be at a relatively low level with respect to fundamental research.

In the following paragraphs of this section, the recent trend of Japan's science and technology will be discussed along with related policy measures employed by the government and strategies adopted by private enterprises.

Basic Policy Measures for Science and Technology Adopted by the Cabinet

In recent years, as science and technology became more deeply connected with economy and society and the standard of Japan's science and technology was raised higher, the Japanese came to increasingly recognize that promoting creative science and technology and contributing to the world is an important task to be tackled as a country advanced in science and technology. Under these circumstances, the government felt it more and more necessary to clarify the basic policies to adopt for the promotion of science and technology and thereby facilitate its systematic promotion. In March 1986, the Cabinet decided on an outline of policy measures for science and technology based on a report submitted by the Science and Technology Council.

In this outline, it is stated that highly creative science and technology should be promoted and that consideration should also be given to the development of science and technology harmonized with human beings and the evolution of science and technology with importance attached to internationality.

The Cabinet's decision on this outline stressing the promotion of creative science and technology may be said to have marked the beginning of a new phase of development of Japan's science and technology.

Measures for Enhancing Fundamental Research

What is most important for Japan in promoting creative science and technology is to positively conduct a wide range of fundamental research, getting rid of its inclination to count on technologies licensed by foreign companies.

The government has implemented various measures to promote fundamental research. Recently, private enterprises are also more inclined than before to conduct research and development from a long-term point of view so as to develop, from scratch and by themselves, original technologies that can support them in the future.

The measures recently implemented by the government to enhance fundamental research include the establishment in FY 1981 of the science and technology promotion adjustment expense system and the creative science and technology promotion system to be administered by the Research Development Corporation of Japan. In FY 1986, when the outline of policy measures for science and technology were decided on by the Cabinet, the international frontier research system was formulated in the Institute of Physical and Chemical Research. It can be seen that the government has steadily been implementing measures to enable fundamental research to be facilitated in internationally open systems.

Establishment of Research Exchange Promotion Law and Recent Major Moves Observed in National Research Institutes

In Japan, against a backdrop of research and development activities being upgraded and expanded in both the academic and commercial sectors in recent years, it is now required that research exchanges be further promoted between different organizations and fields without confining research activities only in the existing research institutes. In FY 1986, the research exchange promotion law that enables foreign researchers to be employed in Japan to engage in research work as public officials was established to further promote research exchanges between Japan and other countries.

While the role to be played by the government to enhance fundamental research has been expanding, private enterprises have been stepping up their R&D activities and the social and economic needs have been changing. The national research institutes are required to further expand and enhance fundamental and leading edge research. Furthermore, it is also essential that they prepare themselves for upgraded research, expand research exchanges with other research institutes, and promote the transfers of techniques and know-how to and from other research institutes. With the research exchange promotion law enforced, the national research institutes have been trying to upgrade, qualitatively and quantitatively, their association with the industrial and academic sectors as well as overseas organizations.

In August 1987, the Science and Technology Council submitted its No 13 report titled "The Way the National Research Institutes Should Work From a Long-Term Point of View." The report pointed out, from the viewpoint of vitalizing the national research institutes, the necessity of reviewing the roles to be played by the national research institutes and their organization and improving the way in which research activities are managed and the circumstances under which research is conducted. The national research institutes have been asked to tackle an important task of enhancing fundamental and leading edge research with the aim of sowing the seeds of new technologies.

Main Moves Recently Observed in Universities

The universities play a central role in fundamental research in Japan. They are now trying to further advance fundamental and creative scientific research so as to promote science worthy of international evaluation. In order to further promote scientific research conducted at universities, the extraordinary education council recommended in its report increasing the amount of subsidies for scientific research, vitalizing the scientific research systems at universities, and promoting scientific exchanges on an international level.

Recently, great public interest was shown for the significance of joint research. In FY 1987, joint research centers will be opened in three universities including Yoyama University which are intended to promote

joint research between universities and private enterprises. Furthermore, to vitalize education and research work at the national universities, they will be permitted, from FY 1987, to found chairs or establish research departments to be financed by private donations. As described above, the cooperative and associative relationships between the Japanese universities and private enterprises are being strengthened.

Major Moves Recently Observed Among Private Enterprises

While the national universities and research institutes are trying to enhance their research activities centering on fundamental research, the Japanese private enterprises comprising a major driving force for research and development are now required to take measures to cope with recent various changes in the international situation, for example, growing trade tensions and sharp rises in the yen's exchange value.

Under these circumstances, the Japanese enterprises are positively engaged in R&D in order to make new developments in their business, while holding their production techniques at the world's top level. This posture may be said to be reflected in the results of the survey of the research activities of private enterprises for FY 1987 conducted by the Science and Technology Agency in May 1987. The results indicated that, even though the Japanese enterprises suffered a sales decrease in FY 1986 due to the appreciation of the yen, they increased their R&D budgets.

It is recently noticeable that the Japanese private enterprises are increasingly inclined to positively tackle fundamental research on their own. In recent years, many enterprises constructed their central laboratories or fundamental research institutes, it is therefore said that the second laboratory-construction boom is on. This move may indicate that they began embarking on long-term R&D work, looking ahead to the 21st century rather than 5-10 years in the future.

Increasing Role of Science and Technology for Regional Development

The number of local areas where industry is facing difficulty--having been hit hard by the sharp appreciation of the yen's exchange value and the subsequent industrial restructuring--has been increasing. In this situation it is imperative for Japan to form a domestic demand-oriented large-scale economic structure and enable its regional industries to gain self-induced continuous vitality.

At present, there is a move toward changing the centralized social structure into a multipolar one in which the social functions are decentralized. This is aimed at facilitating the development of the nation's land in a balanced way. As science and technology comes to be more closely related with the economic society and the construction of nationwide information and communication networks advances at a rapid pace, science and technology has started to draw attention as a key to the vitalization of regional economic societies. It is now strongly recommended that scientific and technological capabilities closely associated with local societies be nurtured and enhanced in the respective

areas. Based on this point of view, the number of plans worked out for regional development has remarkably increased of late. These plans include not only those for development centering around the factory sites but also those for development centering around where research institutes and development functions are to be located. The local autonomous governments have also been implementing measures to promote region-oriented science and technology. These measures include, for example, the inauguration of councils for the promotion of local science and technology.

Other Moves Recently Observed Regarding Science and Technology

As science and technology makes rapid progress, the government's departments and bureaus in charge of science and technology-related policy making are also required to organize administrative systems that can meet the needs of the times. From this point of view, the Science and Technology Agency was reshuffled in FY 1986 based on a report submitted by the administrative reform deliberative council. The reshuffled organization has been promoting various policy measures.

A project worth special mention as a measure for enhancing the foundation for the promotion of science and technology is the construction underway of Kansai cultural and scientific research city in the Keihanna Hill area. The city should become a base for carrying out creative activities in the fields of culture, science, and research with an eye on the 21st century. The Kansai cultural and scientific research city construction promotion law enacted in 1987 is intended to facilitate the planning and implementation of the construction of the city.

In Japan--which has come to hold a considerably influential position both politically and economically among the advanced countries--a move to found, with the aim of promoting science and technology on a global basis, international prize systems for honoring researchers who have made an outstanding contribution to the progress of science and technology has recently surfaced. The prize systems include the Japan Prize founded by the International Science and Technology Foundation, the Kyoto Prize founded by the Inamori Foundation, and the International Biology Prize founded by the International Biology Prize Committee.

Professor Tonegawa of MIT winning the Nobel Prize in physiology for 1987 is also worthy of special mention. The prize was awarded him for his research work while at a Swiss laboratory. It should rate special note that the achievement of a Japanese researcher working in the international arena has been honorably recognized.

The sudden turnaround recently observed in the field of superconductivity research and development is another scientific topic worthy of particular mention. A new superconductor was discovered in January 1986. As a result, superconductor research has become very active worldwide since the end of the same year. In Japan, too, a high level of research work on superconductors has been conducted in the industrial, academic, and public sectors, both independently and jointly.

Predicted Future Trend in Science and Technology

Next, the predicted future trend in science and technology will be discussed based on the results of the fourth technical predictions survey carried out by the Science and Technology Agency over 1986 and 1987.

In the survey conducted by the Delphi method, over 2,000 technical experts were asked to predict the times when important technical tasks (totaling 1,071) which are expected to be tackled in Japan during the coming 30 years (until 2015) would be accomplished and assess the importance of such technical tasks.

Regarding the results of the survey, it can generally be said that research subjects of high importance are included mainly in fields such as "life sciences" and "health preservation and medical care," or fields associated with international information networks, for example, "information, electronics, and software," "communications," "space," and "the earth." This reflects the aging of the constituents of society, the formation of an information-oriented society, and the globalization of various activities that have recently been progressing in Japan.

Greatest importance was attached to "the development of an effective means of preventing cancer metastasis" (predicted year of materialization: 2002) and "the practical application in industrial electric machines of a superconductor with a critical temperature higher than liquid nitrogen (77 K)" (predicted year of materialization: 1994). They are followed by "earthquake prediction" and other research subjects in the fields of nuclear energy, information processing, and communications.

The research subjects whose importance has grown remarkably from when a similar survey was conducted 5 years ago include "explanation of memory mechanism," "explanation of aging mechanism," and "prevention of senile dementia." The fact that these research subjects have been given much greater importance is consistent with the recent aging of the constituents of society and the recent rapid expansion of studies in life sciences.

When the results of this survey are reviewed in a "crosscutting" manner, it can be seen that the research subjects where importance is attached to the explanation of theories and phenomena and where internationality is regarded as important have generally been given greater importance this time. Such subjects include fields closely related to the existence of human beings such as "life sciences," and "health preservation and medical care" or those where international association is considered important, for example, "the earth" and "the environment." Many research subjects where international joint research is thought to be most suitable fall into these fields. According to the results of the survey conducted 10 years ago, the research subjects where importance is attached to international joint research accounted for only about 20 percent of all research subjects, but the proportion based on the results of the recent survey is 40 percent or more. This strongly reflects the increased importance recently attached to the internationality-oriented research posture in the field of science and technology. There are many research subjects falling in the area where

importance is attached to the explanation of theories and phenomena, centering on "life sciences," related to living things. Many are different tasks with the predicted times of materialization very far in the future. The tough research targets where a lengthy time before materialization is predicted are generally given great importance. This may also be an indication that it is now thought necessary in Japan to enhance fundamental research.

Progress of the Internationalization of Japan's Science and Technology

As the R&D activities in Japan have quantitatively expanded, they have come to account for a larger proportion of the R&D activities conducted in the world, enabling Japan to have a greater influence on the world's science and technology. In this situation, the trends in Japan's science and technology have drawn attention from other parts of the world. At the same time, it is expected that Japan make a contribution to the world in proportion to its position in international society. The internationalization of Japan's science and technology can be regarded as a major current of the qualitative change accompanying the quantitative expansion of R&D activities in the country.

In the past, Japan introduced basic technologies from advanced countries in Europe and America aiming at catching up with them and took great technological strides by promoting research and development centering on production technologies. Today, Japan has developed into an industrial nation ranked with the advanced countries in Europe and America. From now on, Japan should promote fundamental research to develop fundamental technologies and thereby contribute to the world. The progress of science and technology intrinsically tends to be accelerated through international competition and cooperation and the objects of the recent highly advanced and sophisticated science and technologies are wide ranging and highly diversified. When this situation is taken into consideration, it can be said that, in order to enable further development of science and technology with the goal of creating a richer society and life for the people in the 21st century, Japan should take more positively than before, internationally oriented policy measures, for example, the promotion of international scientific exchanges and joint research work.

While the rapid growth of Japan's national strength attributable to its advance in science and technology has caused trade friction in various parts of the world, it has also brought Japan the duty to make a greater contribution to the world. It is, therefore, increasingly important for Japan to fulfill its duties as an advanced country, stressing international cooperation and contribution to the world. Japan's contribution will eventually benefit the prosperity of Japan itself.

Chapter 1. Japan's Science and Technology Gaining a Foothold in International Society

Japanese economy and society have progressed remarkably through the half century after World War II. Its GNP grew from ¥8 trillion in FY 1955 to ¥321 trillion (accounting for about 10 percent of the gross international product) in FY 1985. The role played by Japan in international society has been expanding rapidly and the expectations placed on Japan by other countries have also been growing.

In this chapter, the improvement of Japan's science and technology and the background of the improvement, the recent condition of R&D activities in Japan, and Japan's position among the advanced countries with respect to science and technology will be discussed using science and technology-related data such as those on R&D investments, human resources for R&D, and technology trade.

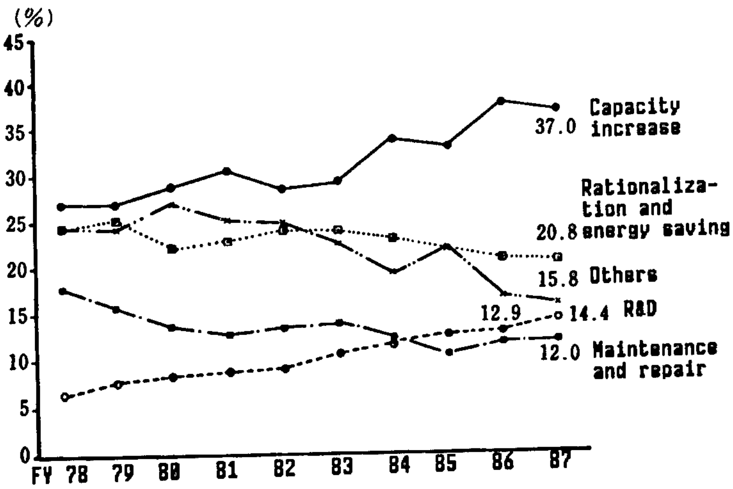
(1) Trend of Japan's Science and Technology With Respect to Capital and Human Investment in Research

In this section, the background of the improvement in Japan's science and technology achieved after World War II will be discussed centering on the aspects of capital and human investment in research. In the discussion, the recent active R&D activities observed in the private sector will be described and an attempt will be made to describe where Japan is positioned in international society.

Positive R&D Investments Mainly Made by Private Enterprises

Research expense statistics gathered in different countries cannot be directly compared, but they can be used to determine a general trend. With respect to total annual R&D expenditures, Japan ranked lowest among the major industrial countries comprising the United States, Germany, France, Britain, the USSR, and Japan itself, in 1955. The total expenditures recorded in Japan in that year accounted for only about 1 percent of the combined total for the six countries. Japan ranked fourth among the six countries in 1975 and its total R&D expenditures for that year accounted for about 10 percent of the combined total. Similarly, in 1985 Japan ranked second, next only to the United States, in the free world and the ratio of its total R&D expenditures to the combined total reached about 16 percent (Figure 1.1.1).

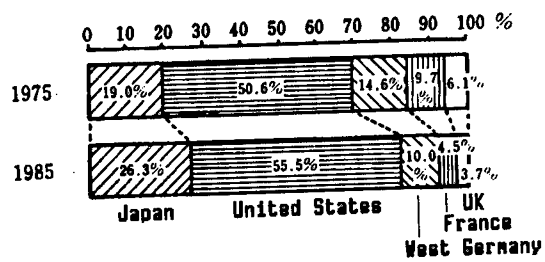
In Japan, the private sector makes the largest proportion of R&D investments. In 1985, private sector R&D investments accounted for about 80 percent of the total R&D investments. Based on the figures gathered in the respective countries, the total R&D investments by Japan's private sector in 1975 accounted for 19 percent of the combined total R&D investments of the private sectors of the six countries. The figure rose to 26 percent in 1985 (Figure 1.1.2). The positive posture of the Japanese enterprises with respect to R&D investment may be regarded as a factor behind its rapid industrial and technological development.



Note: Based on figures recorded for up to FY 1986 and those estimated for FY 1987

Data source: "Survey of Equipment Investment Plans for FY 1987 and 1988" conducted by Japan Development Bank

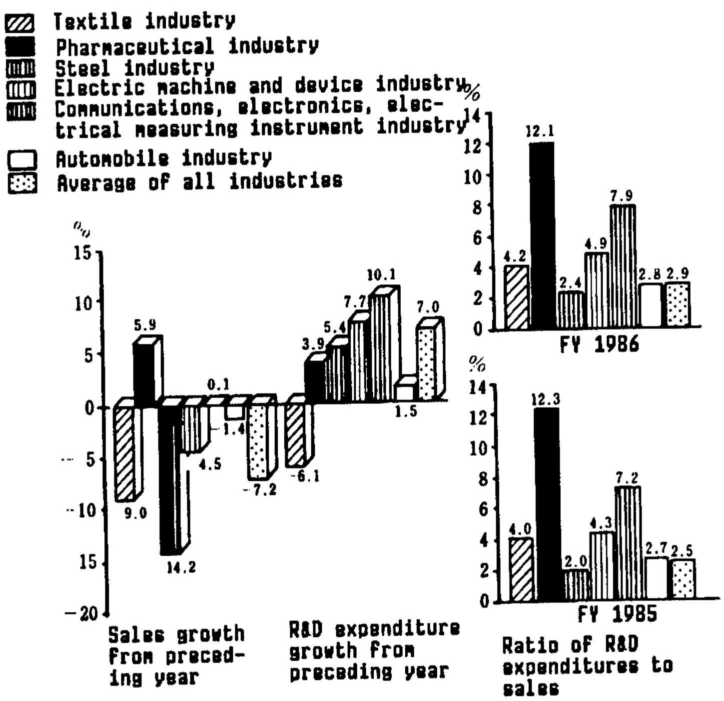
Figure 1.1.1. Change in R&D Expenditures in Major Industrial Nations (Including the United States, Japan, the USSR, West Germany, France, and Britain)



Data source: Attached Material 1

Figure 1.1.2. Proportion of Each Country's Share in the Combined Total Private Sector R&D Expenditures of the Five Major Industrial Nations

According to the results of the survey of "R&D Activities of Private Enterprises in FY 1987" the Science and Technology Agency conducted in May 1987 covering 1,186 private enterprises (responses received from 750) to study the recent R&D investment trend in the Japanese private sector, most enterprises have been increasing their R&D investments at high rates despite the fact that their sales suffered due to the sharp appreciation of the yen over FY 1985 through 1986. This trend is particularly noticeable in such industries as communications, electronics, electrical measuring instruments, electrical machinery and devices, and medicines. The ratio of the R&D expenses of the private enterprises to the amount of their sales also sharply rose from 2.5 percent in FY 1985 to 2.9 percent in FY 1986.



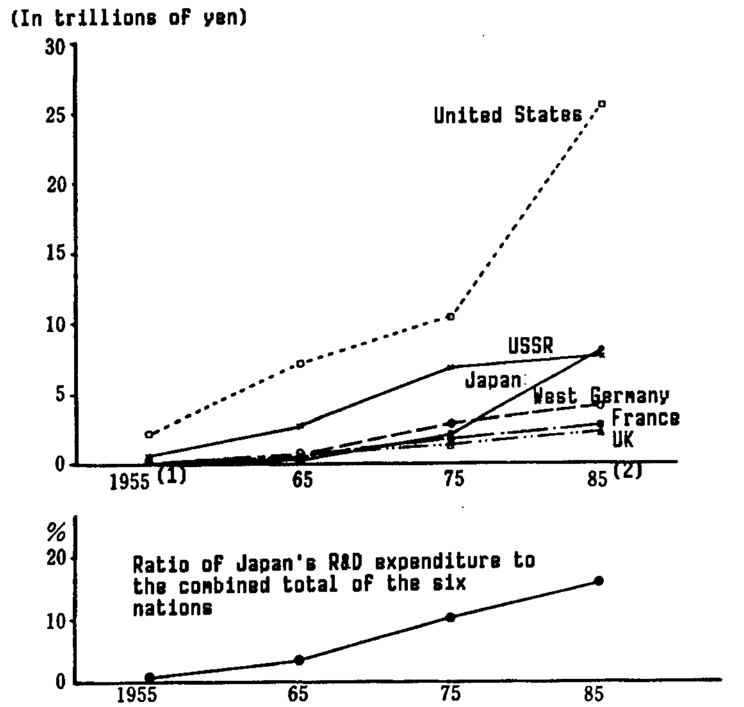
Data source: "Survey of R&D Activities of Private Enterprises (FY 1987)" compiled by Science and Technology Agency

Figure 1.1.3. Gross Sales of Private Industry in FY 1986 and Their Yearly Growth Rates in R&D Expenditures Over Preceding Fiscal Years

The ratio has remained high particularly in the industries such as medicines, communications, electronics, and electrical measuring instruments (Figure 1.1.3).

The R&D investment trend outlined above may indicate that the Japanese enterprises consider it very important to positively promote R&D in order to secure their survival. According to the results of the survey of equipment investment plans for FY 1987 (Figure 1.1.4) conducted by the Japan Development Bank, the ratio of funds invested in R&D to the total amount of investments made in the manufacturing industry has been rising year by year (12.9 percent in FY 1986 and 14.4 percent in FY 1987). This also indicates that the private enterprises attach importance to R&D in their business strategy. It is thought that the enterprises positively promote R&D with the aim of introducing higher-value added products while promoting the diversification of their business by extending their line in different directions or branching out into fields totally new to them.

The positive R&D investments by private enterprises can be seen also from the fact that the number of laboratories constructed by enterprises has been increasing for the past several years.



(Note 1) Figures used for West Germany and USSR are based on statistics compiled in 1956.
(Note 2) Figure used for UK is based on statistics compiled in 1983 and that used for USSR is based on statistics compiled in 1984.
Data source: Attached Material 1

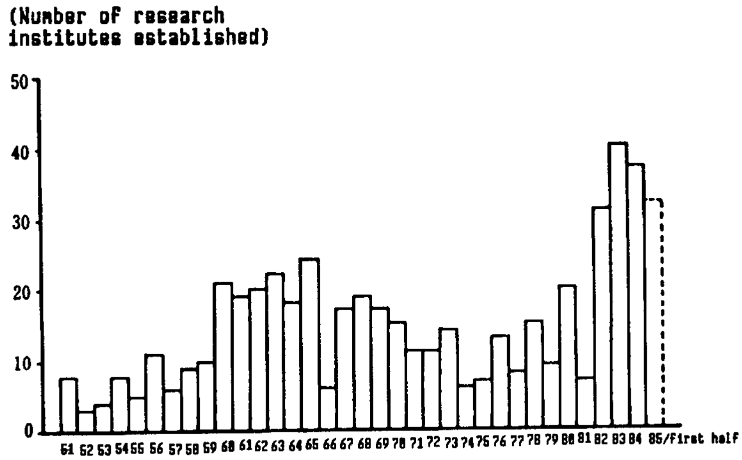
Figure 1.1.4. Time-Series Change in Factors Motivating Investment in Manufacturing Industry

Figure 1.1.5 shows the number of laboratories established by private enterprises in each fiscal year since FY 1951. It shows that the so-called central laboratory construction boom occurred in FY 1960 and remained for several years and that an even greater laboratory construction boom began several years ago.

The laboratories recently constructed by private enterprises include many designed to be used for basic research or other special purposes. This is characteristic of the present laboratory construction boom, in contrast to the previous one during which many enterprises constructed their first laboratories. At the same time, the characteristic of the present boom can also be regarded as reflecting the private enterprises' posture of attaching great importance to R&D.

Changes in R&D Expenditures by Industry

Table 1.1.6 lists the proportions of R&D expenditures of different industries to the combined total amount of all industries for different fiscal years. As can be seen from the table, in FY 1965, the chemical industry was at the top with respect to the amount of R&D expenditures, followed by the electrical machine industry.



Excerpted from: "Chosa [Survey] No 90" compiled by the Japan Development Bank based on data gathered from the following sources:
--For period up to FY 1982:
Japan Research Institute Directory, 1983-1984, compiled under the supervision of the Science and Technology Agency
--For period from FY 1983 to first half of FY 1985;
NEES-IR newspaper articles
(Research institutes established by enterprises capitalized at ¥1 billion or more have been covered.)

Figure 1.1.5. Long-Term Change in Number of Research Institutes Established in Given Years by Private Companies

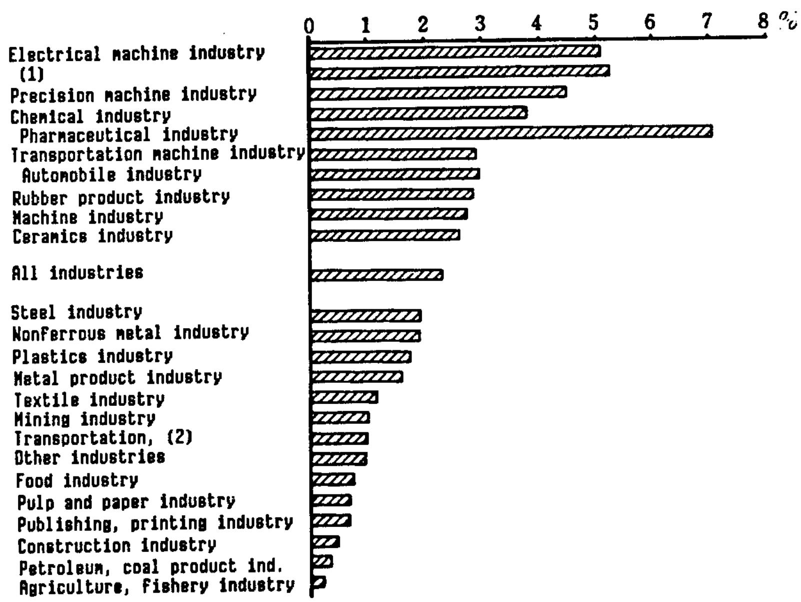
Table 1.1.6. Changes in R&D Expenditures by Industry
(Amount: Millions of yen; Ratio to total in percent)

Industry	Amount	Ratio	Amount	Ratio	Amount	Ratio
Textile industry	80	3.2	226	1.3	626	1.1
Chemical industry	625	24.8	3,221	19.1	9,364	15.8
Pharmaceutical industry	146	5.8	952	5.7	3,419	5.8
Steel industry	148	5.9	892	5.3	2,404	4.0
Machine industry	178	7.1	1,155	6.9	3,827	6.4
Electrical machine industry	511	20.2	4,005	23.8	19,382	32.6
Communications, electronic/electrical measuring instruments industry	312	12.4	2,338	13.9	13,220	22.3
Transportation machine industry	261	10.3	2,895	17.2	9,357	15.8
Automobile industry	214	8.5	1,950	11.6	7,972	13.4
Precision machinery industry	54	2.1	359	2.1	2,017	3.4
Transportation, communications, utilities	126	5.0	807	4.8	2,593	4.4
All industries combined	2,524	100	16,848	100	59,399	100

In FY 1975, the electrical machine industry overtook the chemical industry and the transportation machine industry showed a large increase in the amount of R&D expenditures compared with that recorded in FY 1965.

In FY 1985, the electrical machine industry was again at the top with its R&D expenditures accounting for about one-third of the combined total R&D expenditures of all the industries. In this fiscal year, compared with FY 1975, the communications, electronics, and electrical measuring instrument industry showed a large growth in R&D expenditures, accounting for about 22 percent of the combined total of all industries. The proportion of the transportation machine industry decreased from that recorded in FY 1975, but the proportion of the automobile industry, which is included in the transportation machine industry rose to 13.4 percent.

As seen from the above, the funds invested in research and development by the Japanese private enterprises have been growing year by year, with large proportions accounted for by investments made by the enterprises in fields constituting the mainstream of the world's industry at the respective times.



(1) Communications, electronics, and electrical measuring instrument industry
(2) Transportation, communications, public utilities

Data source: "Report on Science and Technology Research Survey" compiled by the Statistics Bureau of the Management and Coordination Agency

Figure 1.1.7. Ratio of R&D Expenditures to Sales by Type of Industry (For FY 1985)

In terms of the ratio of R&D expenditures to sales, such industries as the electric machine industry and chemical industry which are ranked high with respect to the ratio of R&D expenditures to the combined gross R&D

expenditures of all industries also show high figures. From this, it can be said that the positive R&D investments by Japanese enterprises centering on high-technology fields have resulted in increasing their sales, and contributing to the strengthening and vitalization of their corporate constitution (Figure 1.1.7).

Trend of Research and Development by Private Enterprises

Table 1.1.8 lists the rates of R&D expenditure concentration on main business areas in major manufacturing industries. The rates have been calculated, to analyze the recent trend in the R&D activities of Japanese enterprises, based on the statistics of private enterprises' research expenditures by product type given by the "Report on Science and Technology Research Survey" compiled by the Management and Coordination Agency.

Table 1.1.8. Rates of R&D Expenditure Concentration on Main Business Areas in Major Manufacturing Industries (in percent)

Industry	FY 1970	1975	1980	1985
Textile industry	47	41	30	28
Chemical industry	92	93	94	91
Oil, fat, paint industry	71	57	53	46
Pharmaceutical industry	85	92	94	94
Rubber products industry	88	92	88	86
Ceramics industry	77	62	56	55
Steel industry	75	78	79	66
Electrical machine industry	89	89	90	90
Communications, electronics, electrical measuring instrument industry	98	98	94	95
Transportation machine industry	85	78	85	86
Automobile industry	89	88	93	93

Data source: "Science and Technology Research Survey Report," Statistics Bureau, Management and Coordination Agency

The industries listed in Table 1.1.8 can be divided into two groups: one comprising industries in which the ratios of R&D expenditure concentration on main business areas are high and the other industries in which the ratios are low. For the former group including the pharmaceutical industry, the communications, electronics, and electrical measuring instrument industry, and the automobile industry, the ratios stayed nearly constant or rose in the last 15 years. For the latter group including the textile industry, the oil, fat, and paint industry, and the ceramics industry, the ratios generally declined during the same period.

The former group of industries are associated more with advanced technologies in fields such as biochemistry and electronics. It can be seen that this group of enterprises has been positively investing in research and development in their main business areas. The latter group, on the other hand, comprises old-established industries such as the

ceramics industry. In this industry, for example, the funds invested in research work for the development of communications, electronic products, and electrical measuring instruments has been rapidly increasing in recent years. In 1970, the proportion of research funds used for the development of the abovementioned types of products to the total amount of R&D expenses in the ceramics industry was 1 percent. It reached 11 percent in 1985, indicating that the enterprises in this industry have been making positive investments to branch out into fields, where their technologies can be utilized, of different industries.

The above described trend of R&D investments by private enterprises indicates that many enterprises have been adopting strategies for branching out into different fields, particularly high technology areas against a backdrop of increasingly sharp competition from newly industrializing countries (NICS) due to the rising value of the yen. They appear to be steadily gearing up to cope with the new wave of internationalization of the Japanese industry.

Table 1.1.9. Proportion of R&D Expenditures by Nature of Work in Private Sector

(In percent)

		Basic research	Application research	Development work
Japan	(1985)	5.9	21.9	72.1
United States	(1986)	3.6	19.9	76.6
West Germany	(1983)	4.9	95.1	
France	(1983)	3.0	30.6	66.4
Britain	(1981)	2.5	20.0	77.5

Note: The basic research only in natural sciences has been taken into account for Japan and Britain. For other countries, the basic research in cultural and social sciences has also been counted.

Data sources:

Japan--"Science and Technology Research Survey Report," Statistics Bureau, Management and Coordination Agency

United States--"National Patterns of Science and Technology Resources," NSF

West Germany, France, Britain--Statistics compiled by OECD.

Next, the trends of R&D expenditures by nature of work of the private sectors of different countries will be discussed. The figures listed in Table 1.1.9 are based on relevant statistics compiled in different countries. Even though accurate analysis cannot be made by directly comparing figures gathered in different ways, it can be said for every country listed in the table that the R&D funds are used mostly for research

on applications and product development and that the funds appropriated for basic studies account for the smallest proportion. This is understandable since the private enterprises are profit oriented.

Figure 1.1.10, prepared to study the degree of stress placed on basic research work in various industries, shows the ratios of R&D expenditures to sales and ratios of expenditures for basic research to the total R&D expenditures in different industries. As can be seen from the figure, it is a general tendency that, as the ratio of R&D expenditures to sales rises, that of the basic research expenditures to the total R&D expenditures also increases. Particularly sharp increases in the proportions of basic research expenditures are observed in such industries as pharmaceutical, food, and ceramics.

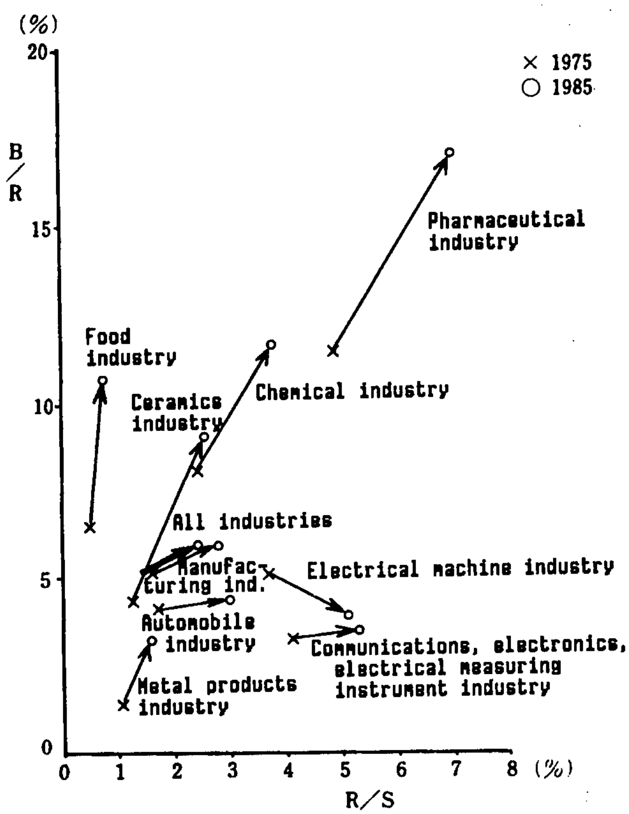


Figure 1.1.10. Ratio of R&D Expenditures to Sales (R/S) and Ratio of Basic Research Expenditures to Total R&D Expenditures (B/R), by Type of Industry
Data source: "Science and Technology Research Survey Report," Statistics Bureau, Management and Coordination Agency

Recent Trend of Enterprise Advances Into and From Japan

While the Japanese enterprises have been positively investing in research and development and have thereby been steadily improving their technologies, an increasing number of foreign enterprises are planning to establish research footholds in Japan.

Table 1.1.11. Number of Facilities of Foreign Capital Companies To Be Operating in Japan in 1987-1989 (including those of U.S.-capital companies)

		Number of plants	Number of plants with R&D facilities
Total		68	23
Chemical, pharmaceutical		32	13
Machinery		19	7
Others		17	3
U.S.-capital companies among the above	(53%)	36	13
Chemical, pharmaceutical	(50%)	16	5
Machinery	(42%)	8	5
Others	(71%)	12	3

Data source: "Chosa No 108," Japan Development Bank, based on data contained in NIPPON RITCHI NEWS [JAPAN INDUSTRY LOCATION NEWS], etc.

The number of foreign capital enterprises planning to establish plants in Japan between 1987 and 1989 is broken down by industry in Table 1.1.11. Of the total 68 plants planned for construction in Japan by foreign enterprises, about one-third are scheduled to incorporate R&D facilities. From this, it is assumed that a considerable number of foreign enterprises scheduled to build plants in Japan intend to use the plants not only as production or information gathering footholds but as R&D bases. By industry, the chemical and pharmaceutical industry includes the largest number of foreign enterprises planning to use their Japanese facilities as R&D bases.

The above move indicates that many foreign enterprise highly rate the level of Japanese technologies and find Japan attractive not only as a market for their products but also as bases for their R&D activities.

According to the results of a survey of the overseas activities of Japanese enterprises recently conducted by the Ministry of International Trade and Industry, many of the Japanese enterprises engaged in OEM exports began at the strong request of foreign companies. This is another indication that the production techniques of Japanese enterprises are rated highly by foreign companies.

While an increasing number of foreign enterprises have been gaining access in Japan, the number of Japanese enterprises advancing into foreign countries has also been increasing.

According to the results of recent surveys of the moves among Japanese enterprises to advance into foreign countries the manufacturing industry enterprises as discussed in detail in Chapter III, can broadly be divided into two groups: those which are positive about establishing overseas production footholds and those extremely negative towards the idea of having overseas production facilities. Many enterprises belonging to the "positive" group are found in the communications, electronics, and electrical measuring instrument industry and automobile industry, whereas many of those in the "negative" group come from the steel industry, ceramics industry, and food industry. With respect to research and development, few Japanese enterprises have established facilities in foreign countries. It appears that they intend to promote R&D activities mainly in Japan.

According to the results of the "survey of enterprise' activities in FY 1986" conducted by the Economic Planning Agency, it is likely that the proportion of the Japanese enterprises that cite as reasons for considering overseas production "to cope with the yen's appreciation adversely affecting their competitive position" and "to market their products in foreign countries where the products are subject to import regulations" will rise from now on.

All that has been discussed above indicates that an increasing number of Japanese enterprises, mainly those in high technology fields, have been advancing into foreign countries against a backdrop of the rising exchange value of the yen. Some people are apprehensive that the R&D capability of Japanese enterprises might suffer from the transfer of their production facilities to foreign countries. However, the results of a relevant survey indicated that the enterprises supporting the view that "the transfer of production facilities to foreign countries will adversely affect the technological chains in Japan possibly causing the domestic R&D capability of the Japanese enterprises to decline" accounted for only 9 percent of the total number of enterprises covered by the survey.

The results also indicated that many of the Japanese enterprises that have acquired overseas R&D facilities intend to use them mainly to directly grasp the needs in foreign markets and that about 60 percent of the enterprises surveyed feel that they should maintain principal R&D bases in Japan. The enterprises apparently think it necessary to maintain their domestic R&D capability.

Human Resources for R&D

The researchers including those in the fields of human and social sciences totaled 473,000 in Japan as of April 1986. Japan is thus ranked second in the free world, next only to the United States with 790,000 researchers. Table 1.1.12 gives changes in the numbers of researchers in major industrial countries. As seen from the table, in the past 20 years, the

Table 1.1.12. Changes in the Numbers of Researchers in Major Industrial Countries (In 1,000s)

Country	1963	1975	1985
Japan	13.4	31.0	44.8
United States	49.5[2]	52.8	79.0
West Germany	3.3[1]	10.4	12.8[3]
France	3.3	6.5	9.3[4]
Britain	5.9[1]	8.1	9.6[3]
USSR	56.6	122.3	146.4[5]

Notes: 1. 1964
2. 1965
3. 1981
4. 1983
5. 1984
6. The human and social science researchers have been counted in.

Data source: Attached material 1.

number of researchers has grown most sharply in West Germany. The next highest growth took place in Japan.

The number of Japanese researchers in the natural sciences has increased most sharply in the technological area. Recently, the ratio of the number of technology researchers to the total number of researchers in the natural sciences has neared 50 percent in Japan. It appears that the number of researchers has been growing larger in the technological field.

Changes in the proportion of researchers with academic degrees by field in the natural sciences in different countries are shown in Figure 1.1.13. The proportion of physical science researchers with academic degrees to the total number of researchers in the natural sciences in Japan is smaller than that in the United States, West Germany or Britain. Moreover, the proportion has been declining as in the United States and Britain. The proportion of technology researchers to the total number of researchers in the natural sciences in Japan is larger than that in the United States, West Germany or Britain. That is, in Japan, there are more technology researchers than physical science researchers.

It is seen from the results of the survey of the fields in which the graduates of universities and gradate schools found employment in recent years that the number of graduates with academic degrees who found employment in the manufacturing sector has been sharply increasing. Furthermore, among those who found employment after earning a bachelor's, master's or doctor's degree the number of graduates who majored in science has increased. These trends indicate that the private enterprises have been enhancing their basic research.

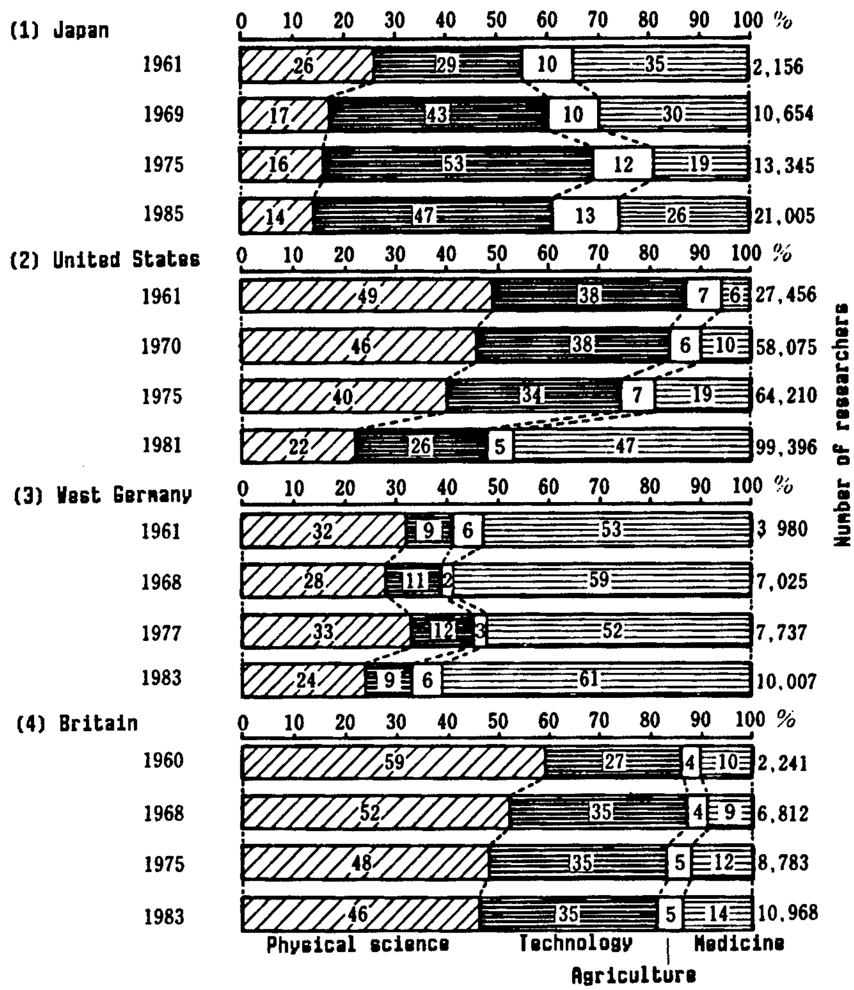


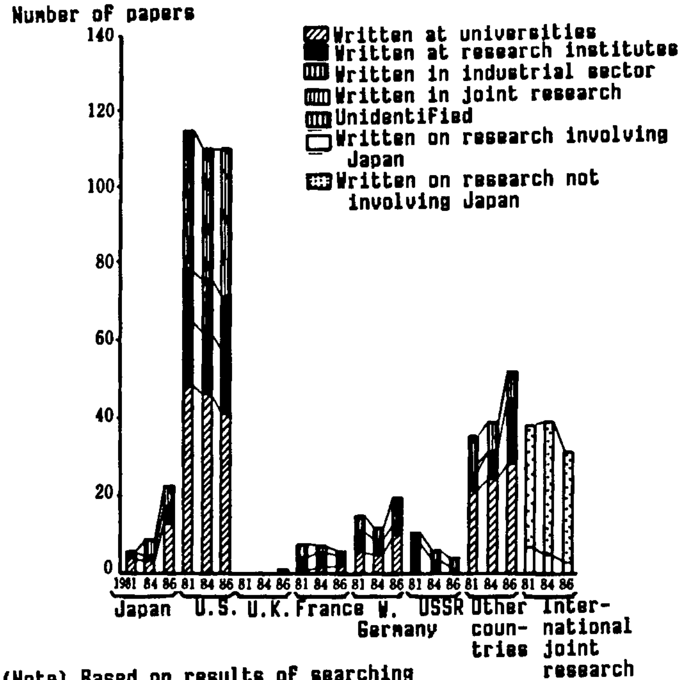
Figure 1.1.13. Proportions of Researchers With Advanced Academic Degrees (MS and PhD), by Field of Science

Note: Graphs on West Germany are based on the numbers of doctors only.
Data source: "International educational index comparison," Ministry of Education

(2) Trend of Japan's Science and Technology Analyzed in Terms of Achievement

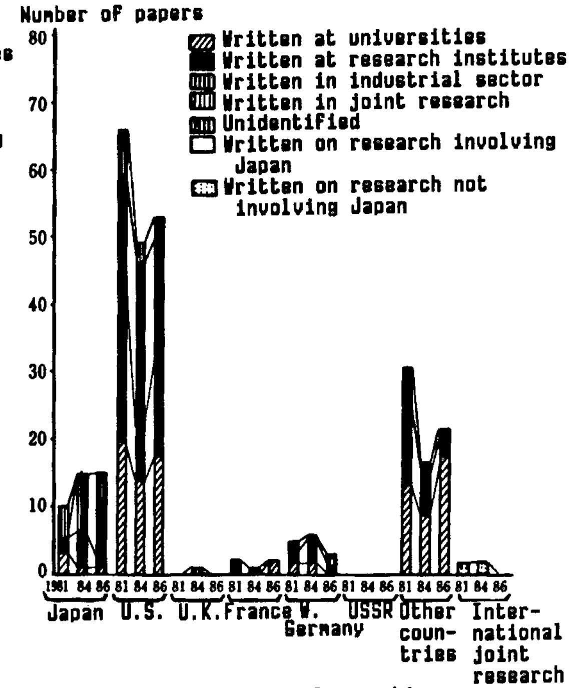
In the preceding section, Japan's position in international society with respect to science and technology has been discussed, focusing on the magnitude of capital and human resource investment in R&D activities. There will be a similar discussion in this section but focusing on the results produced by R&D activities.

(1) Superconductivity



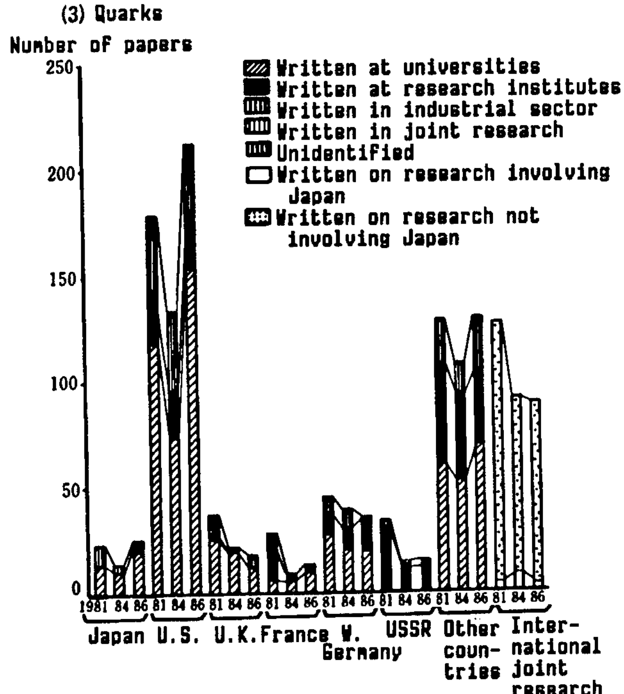
(Note) Based on results of searching science and technology literature file of JICST for original papers published in the following journals:
--PHYSICAL REVIEW B
--PHYSICAL REVIEW LETTERS
--SOLID STATE COMMUNICATIONS

(2) Optoelectronics



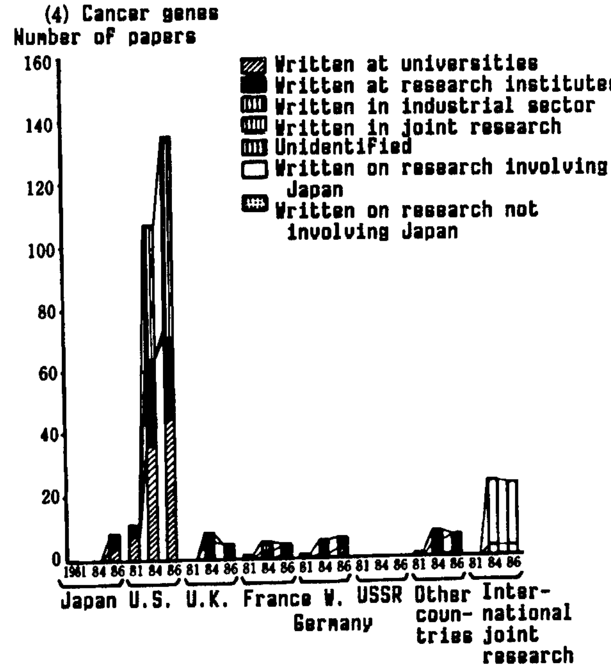
Note: Based on results of searching science and technology literature file of JICST for original papers published in the following journals:
--JOURNAL OF APPLIED PHYSICS
--APPLIED PHYSICS LETTERS
--SOLID STATE COMMUNICATIONS

(3) Quarks



Note: Based on results of searching science and technology literature file of JICST for original papers published in the following journals:
--NUCLEAR PHYSICS B
--PHYSICAL LETTERS B
--PHYSICAL REVIEW D

(4) Cancer genes



Note: Based on results of searching science and technology literature file of JICST for original papers published in the following journals:
--NATURE
--SCIENCE
--CELL
--PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCE OF THE UNITED STATES OF AMERICA

Figure 1.1.14. Comparison by Country and by Type of Institutions in Number of Papers Published in Major Scientific and Technical Journals

Research Papers

In Figure 1.1.14, the number of papers, centering on those in advanced scientific and technological fields, published in major international scientific and technical journals in different years are compared by field of science and country based on data extracted from the science and technology literature file of the Japan Information Center of Science and Technology (JICST).

The four fields, superconductivity, optoelectronics, quarks, and cancer genes, have been covered for this analysis. As Figure 1.1.14 shows, through the years covered, the United States has greatly superseded other countries in the number of papers in these four fields.

All the academic journals selected for the survey in creating the graphs shown in Figure 1.1.14 are reputable ones in their respective fields. The graphs indicate the United States' strength in advanced fields.

As for the field of superconductivity, the number of papers written by Japanese researchers and published in major scientific journals has been increasing. The increase has been remarkable particularly in recent years. In fact, in 1986, Japan overtook West Germany and ranked second next to the United States. By institution type, the papers produced at universities account for a large portion in the respective countries. More than half the papers written in Japan are comprised of those written at universities, but it is noticeable that the number of papers written in the private sector sharply increased in 1986.

In the area of optoelectronics included in the information and electronics field, Japan has been in second place next to the United States through all the years covered by the survey with respect to the number of papers published in major scientific journals. This supports the general view that Japan has great potential in this area.

It is characteristic of the R&D activities in this area that there is little joint research. It appears that partly because the research in this area is already at a stage where practical applications can be developed, independent research is being promoted in individual organizations.

Regarding the number of papers written on quarks in the field of pure basic science, the United States is in top place. Japan compares to Britain and France, but West Germany is ranked higher. This indicates the traditional strength of European countries in this field. It can generally be said that more than half the papers written on quarks in the major industrial countries comprise those written universities. In this area, many joint research projects, mainly on an international basis, are being conducted.

The United States' superiority in cancer gene research is overwhelming. In 1986, a considerable number of papers on cancer genes were written in Japan, pushing Japan to second place. Still, Japan lags far behind the United States. In the United States, the number of papers written on

cancer genes jumped about tenfold, indicating that research progressed rapidly during that period producing abundant results.

As summarized above, the number of research papers written in Japan has been growing larger year by year, even though it is still far lower than that in the United States. Particularly, in the advanced fields such as superconductivity and optoelectronics, the papers written in Japan account for a considerable portion of the papers written in the world.

Table 1.1.15. Comparison of Major Industrial Countries With Respect to Numbers of Papers Published in Scientific Journals and Those Cited by Other Authors

(1) Comparison with respect to the number of papers published in the world's major scientific journals

Research fields covered by this survey	Ranking by number of papers stored in database. Figures in () represent ratios of numbers of papers written in respective countries and stored in database to total number of papers stored in database		Increase in number of papers stored in the database in 10-year period	
	1976 Japan	1985 ranking	Japan	Overall
INSPEC (Physiochemistry)				
--Physics	5 (6)	U.S.(28) USSR(11) JPN (9) W.G.(7) U.K.(6)	1.97	1.44
--Electric/electronic engineering	4 (6)	U.S.(28) JPN (10) U.K.(6) W.G.(6) USSR(4)	2.67	1.40
--Computers	4 (4)	U.S.(31) UK (7) JPN (6) W.G.(5) CAND (3)	2.53	1.79
Chemical abstracts (chemistry)	3 (9)	U.S.(32) JPN (15) U.K.(7) W.G.(5) USSR(4)	2.66	1.66
--Pharmaceutical chem.	3 (9)	U.S.(34) JPN (13) U.K.(7) USSR(7) W.G.(5)	1.66	1.19
--Biochemistry	3 (9)	U.S.(22) JPN (11) USSR(10) U.K.(6) W.G.(5)	1.20	0.94
--Agricultural chem.	3 (11)	U.S.(18) USSR(16) JPN (14) W.G.(9) U.K.(6)	1.16	0.97
--Organic chemistry	3 (13)	USSR(21) U.S.(20) JPN (14) W.G.(5) U.K.(5)	1.19	1.12
--Polymer chemistry	3 (11)	U.S.(23) JPN (17) USSR(16) W.G.(6) U.K.(5)	1.91	1.17
--Chemical industry	3 (13)	U.S.(20) USSR(16) JPN (14) W.G.(9) U.K.(4)	1.33	1.17
--Technical chemistry	3 (9)	USSR(28) U.S.(15) JPN (12) W.G.(6) U.K.(4)	1.20	0.88
--Metallurgical, metal engineering	3 (6)	U.S.(22) USSR(22) JPN (7) W.G.(6) FRNC (5)	1.72	1.36
--Physical chemistry	3 (7)	U.S.(28) USSR(16) JPN (10) W.G.(7) U.K.(4)	2.13	1.47
--Energy				
--Condensed matter physics	3 (9)	U.S.(23) USSR(20) JPN (12) FRNC (6) W.G.(6)	1.76	1.33
COMPENDEX (Engineering)				
--Civil engineering, environmental eng.	4 (4)	U.S.(30) JPN (8) U.K.(7) USSR(6) W.G.(5)	2.80	1.50
--Metal, resource eng.	5 (6)	U.S.(21) JPN (12) USSR 9) W.G.(6) U.K.(6)	2.81	1.40
--Mechanical eng.	5 (4)	U.S.(29) JPN (8) U.K.(6) W.G.(6) USSR(6)	2.61	1.45
--Chemical, agric. eng	5 (6)	U.S.(27) USSR(10) JPN (10) U.K.(6) FRNC (4)	3.37	2.00
--Agricultural, managerial engineering	5 (4)	U.S.(31) JPN (9) U.K.(6) USSR(6) W.G.(5)	4.07	1.96
Excerpta Medica (Medicine)	7 (5)	U.S.(38) JPN (9) U.K.(9) FRNC (6) CAND (6)	3.85	1.93
--Genetics --Physiology	4 (6)	U.S.(49) U.K.(7) JPN (7) CAND (6) W.G.(5)	1.48	1.30
--Cancer study (Fundamental)	2 (8)	U.S.(44) JPN (12) U.K.(7) FRNC (5) W.G.(5)	2.30	1.48
--Cancer study (clinical)	3 (7)	U.S.(34) JPN (12) U.K.(8) FRNC (8) W.G.(7)	2.27	1.38
--Cardiosurgery	6 (6)	U.S.(39) JPN (9) W.G.(7) U.K.(7) FRNC (6)	2.68	1.72

Note: Coauthored papers have been regarded as having been written in countries where organizations to which the first-mentioned authors of respective papers belong exist.

Data source: "International comparison in number of research papers" compiled by research group of Academic Information Center

[Continuation of Table 1.1.15.]

(2) Comparison with respect to the proportion of papers cited by other authors in articles published in scientific journals

Proportion in (%)

Field	Year/ country	Japan	United States	West Germany	France	Britain	Total number of papers cited
Mathematics	1977	1.0	20.0	2.7	5.4	3.2	411
	1982	0.2	36.4	5.5	4.3	2.6	420
Physics	1977	1.8	34.6	3.9	4.7	3.0	19,857
	1982	3.0	36.0	7.4	7.0	3.1	24,771
Chemistry	1977	2.5	30.4	3.5	3.2	3.1	9,440
	1982	3.6	36.5	5.6	5.9	2.5	11,994
Biochemistry	1977	1.4	29.3	4.0	2.7	6.7	5,116
	1982	0.9	41.1	5.6	4.3	7.3	6,511
Earth, space sciences	1977	0.8	32.9	2.4	3.8	6.1	3,569
	1982	2.0	42.9	3.9	6.0	6.1	5,932
Medicine	1977	0.5	30.9	1.4	1.9	18.3	5,971
	1982	1.3	36.7	1.9	2.6	18.9	6,682
Engineering	1977	0.9	32.8	1.4	1.7	3.2	1,461
	1982	2.2	42.1	4.4	4.1	4.3	2,638
Agriculture	1977	1.6	29.1	1.8	2.3	4.2	2,894
	1982	2.0	38.2	4.2	3.3	4.5	3,973
Totals	1977	1.6	38.7	3.2	3.6	5.6	48,719
	1982	2.5	37.8	5.6	5.6	5.5	62,921

Note: Based on classification of data stored in SCI (Science Citation Index) database of the United States. For details, refer to report mentioned below.

Data source: "Report on way international exchanges of scientific and technological information should be" compiled for Science and Technology Agency on a commission basis.

When the major industrial countries including Japan are compared with respect to the number of research papers written and published in major international scientific journals, Japan, where most research papers are written by researchers at universities and research institutes, was ranked either second next to the United States or third next to the United States and USSR as of 1985 in most advanced research fields ranging from physiochemistry and engineering to medical science. The number of papers written in Japan increased remarkably from 1976 through 1985. In fact, during that period, the rate of increase among the seven major industrial countries was highest in Japan and Japan's ranking rose in almost all research fields (Table 1.1.15 (1)).

Table 1.1.15(2) lists the proportions of papers written in different fields in the major industrial countries and cited by other authors in articles published in scientific journals to the total number of papers written in all seven countries combined. In 1982, of all the research papers cited by other authors in articles published in major scientific journals, those written by Japanese researchers accounted for a meager 2.5 percent. Recently, the proportion has been rising steadily, indicating that the quality of papers written by Japanese researchers has been improving little by little.

Patents

In the number of patent applications, Japan ranks first in the world. In fact, its lead in this area over other countries has simply been expanding since it reached the top in 1973. In 1984, about 285,000 patents were applied for in Japan. This number is about double that recorded in the USSR in the same year. Japan also ranks first regarding the number of domestically granted patents. However, with regard to the number of patents acquired in major foreign industrial countries, the United States, West Germany, and Japan were ranked in that order during 1981 through 1984. This ranking does not agree with the number of patent applications where Japan is first. At any rate, Figure 1.1.16 shows that the number of patents acquired in foreign countries has been growing faster for Japan than for other countries.

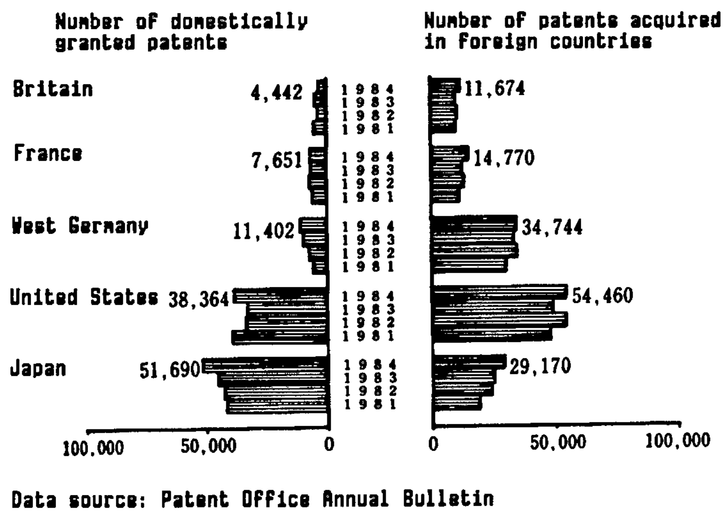
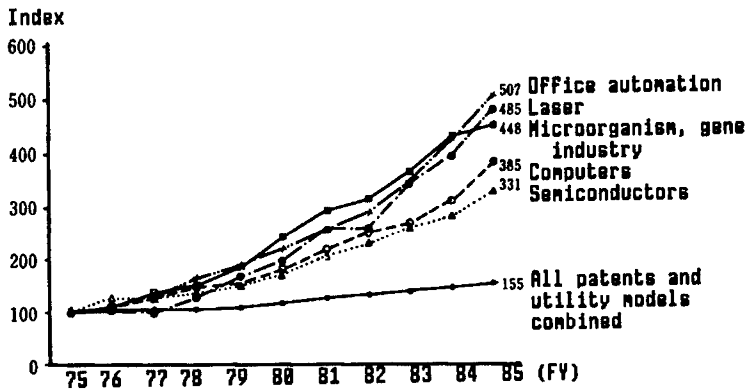


Figure 1.1.16. Change in Number of Patents Granted in Major Industrial Nations

In Japan, the number of patent applications filed in the advanced scientific and technological fields has recently been increasing, showing that technology development in those fields has recently been very active. On the basis of 100 patent applications (including applications for patents and utility models) filed in FY 1975, the patent applications filed in various fields during FY 1985 is as follows: 507 for the office automation

related fields, 485 for the laser related fields, 448 for the fields related with the microorganism or the gene industry, 385 for the computer related fields, and 331 for the semiconductor related fields. These index values that are considerably larger than 155 for all the industries combined also indicate that the numbers of patent applications filed in the advanced scientific and technological fields have been sharply rising (Figure 1.1.17).



Data source: Data prepared by the Patent Office

Figure 1.1.17. Change in Number of Applications for Patents and Utility Models in Selected Areas of Advanced Science and Technology

Balance of Technical Trade

Japan's balance of technical trade is still in the red according to the monthly report on the balance of international trade compiled by the Bank of Japan.

In 1970, the ratio of income to payment in Japan's technical trade stood at 0.13. However, regarding the technical trade based on new contracts, Japan's balance of payments turned black in 1972 and, in 1985, the ratio of income to payment in Japan's overall technical trade rose to 0.31. It seems that the balance of Japan's overall technical trade is gradually improving.

Among other industrialized countries, the United States and Britain have been in the black in their balance of technical trade for the last 10 years. The ratio of income to payment in the United States' technical trade stood at 40.27 in 1986, showing that the country was deep in the black in its balance of technical trade. The ratio was 1.27 in 1983 for Britain.

Like Japan, West Germany and France have been in the red in their balance of technical trade. For the last 10 years, their technical imports have remained at a level about twice as high as that of their technical exports (with the ratio of income to payment in their technical trade at about 0.6).

International Prizes Such as Nobel Prizes

While there have been only five Japanese researchers who have won a Nobel Prize in natural sciences including Dr Susumu Tonegawa (Professor at MIT) who was awarded the prize in 1987 thereby becoming the first Japanese to have won a Nobel Prize in physiology, the Nobel Prize winners total 142 in the United States and 63 in Britain. Even in such countries as Austria, Switzerland, and the Netherlands, where the research expenditures and number of researchers are smaller than in Japan, the number of Nobel Prize winners is more than double that of Japan.

In the field of mathematics, so far two Japanese have received the Fields Prize that is referred to as the Nobel Prize for mathematicians. This number is smaller than that for such countries as the United States and France (Table 1.1.18).

Table 1.1.18. Numbers of Nobel Prize and Fields Prize Winners by Country

Country	Number of Nobel Prize winners 1901-45	1946-47	Last 10 yrs	Number of Fields Prize winners 1936	1950-86	Last 10 yrs
United States	19	123	34	1	10	4
Britain	25	38	6	-	4	1
West Germany	36	18	6	-	1	1
France	16	7	2	-	5	1
Sweden	6	9	4	-	1	-
USSR	2	8	1	-	2	1
Netherlands	8	2	1	-	-	-
Switzerland	4	7	3	-	-	-
Austria	7	1	-	-	-	-
Denmark	5	2	1	-	-	-
Italy	3	4	2	-	1	-
Belgium	2	3	-	-	1	1
Japan	-	5	2	-	2	-
Others	8	16	2	1	1	1
Total	141	243	64	2	28	10

Note: Only the Nobel Prize winners in natural sciences such as physics, chemistry, medicine, and physiology have been counted.

Data source: Nobel Foundation Directory and data collected by the Science and Technology Agency

The Nobel Prize and the Fields Prize are representative of the prizes awarded to the researchers who produce results internationally recognized as brilliant in the field of basic science. Even though the number of Japanese winners is still small, it is expected that the Japanese researchers will make a greater contribution in the field of basic science from now on.

International Comparison With Respect to R&D Capability in Different Fields

The results of a survey of the trend in private enterprises' activities indicate that Japan is generally considered superior to the United States with respect to R&D capability in the manufacturing and processing fields, whereas the United States is generally considered superior to Japan in the fields of materials, electronics, and life sciences. However, the superiority of the United States in the field of electronics is not considered one-sided. More concretely, Japan is thought to be superior with respect to optoelectronics, while the United States is believed to be in the lead in computer software for manufacturing and processing. When compared with European countries, Japan is generally considered superior in the fields of manufacturing, processing, and electronics and inferior in the field of life sciences. However, Europe's lead over Japan in life sciences is not as large as that held by the United States over Japan in the same field (Figure 1.1.19).

When Japan, the United States, and Europe are compared with respect to R&D capability by field, it is generally believed: in materials, the United States is in the lead followed by Japan and Europe which are at about the same level; in electronics (excluding optoelectronics in which Japan is ahead of others), the United States, Japan, and Europe are ranked in that order; in life sciences, the United States, Europe, and Japan are ranked in that order; in manufacturing and processing (excluding computer software in which the United States is superior to others), Japan, the United States and Europe are ranked in that order.

The results of the comparison (made in the 1985 science and technology white paper) of Japan with the countries in Europe and America in terms of their scientific and technological standard and R&D potential also indicate the relations among the three industrial powers similar to those described above. It seems that the ranking of the three by R&D capability has generally been fixed in the order of the United States, Japan, and Europe in recent years.

(3) Japan's Technological Strength and Technology Development Capability

In this section, Japan's technological strength will be assessed quantitatively using various economic data referred to in the foregoing.

There are various ways of quantitatively assessing the technological strength of a country. In this section, Japan's current technological strength will be assessed, based on the method introduced in the 1981 science and technology white paper. In this method, it is considered that the magnitude of the contribution by Japan's science and technology to the current productivity of its industry represents its scientific communications, electronics, and electrical measuring instrument industry technological strength and that its ability to independently develop new products and technologies represents its capability for technology development.

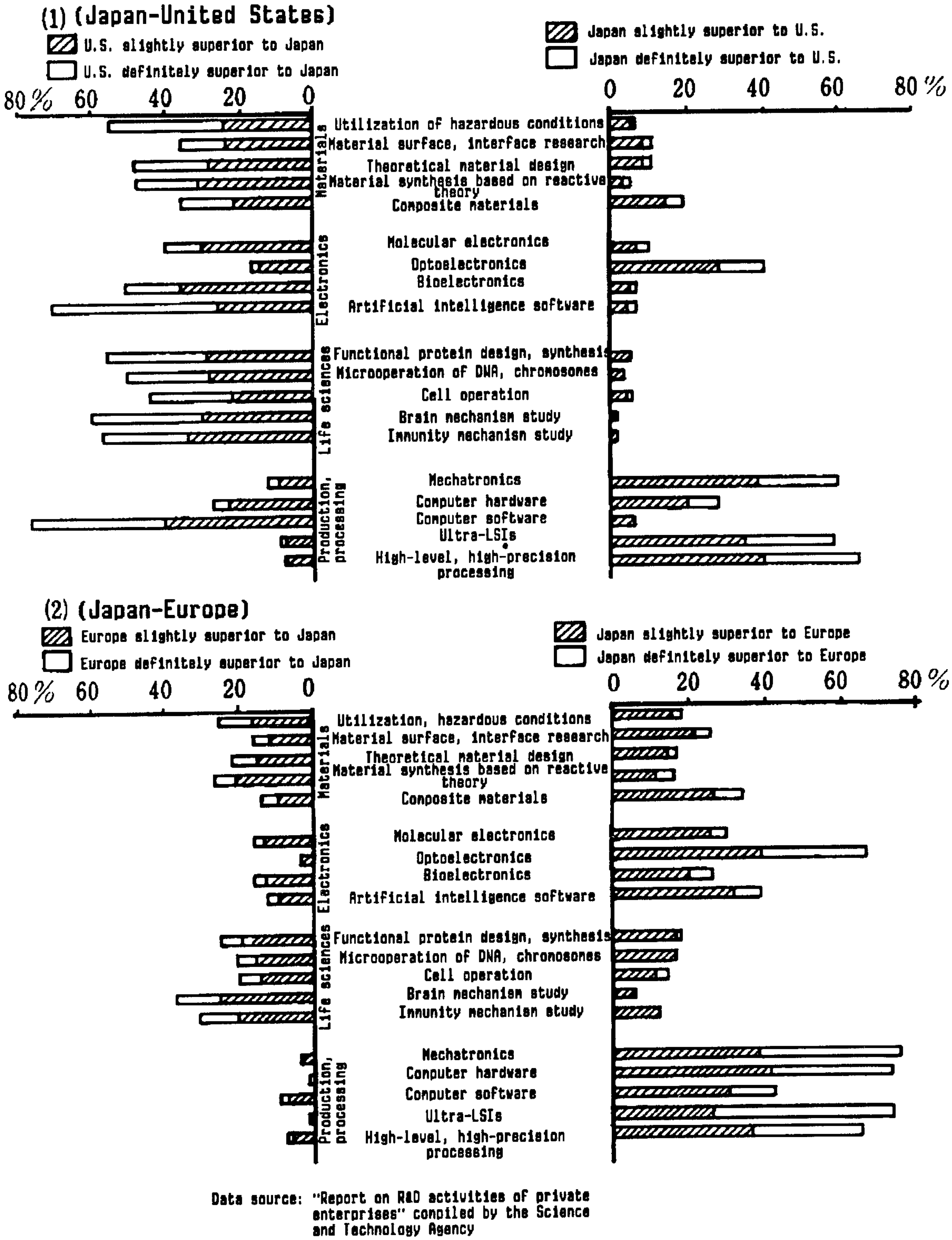


Figure 1.1.19. Japan-U.S. and Japan-Europe Comparisons of Relative R&D Capability, by Field

The method uses the following eight items as representative indicators of the technological strength and technology development capability of a country.

1) Number of patent registrations
2) Amount of technical trade (sum of technical imports and exports)
3) Amount of exports of products yielding technical incentives
4) Amount of value added to manufactured goods
5) Research expenditures
6) Number of researchers
7) Number of patents acquired in foreign countries
8) Amount of technical exports

The above items can be grasped as follows: 1)-3) directly reflect the technological strength of a country; 4) is an indicator of the magnitude of the industrial infrastructure where the technological strength of the country's industry can be utilized; 5)-6) indicate the magnitude of investments in science and technology that constitutes the foundation for improvement of the technology development capability of the country; and 7)-8) reflect the results produced using the country's capability for technology development.

To generally assess Japan's technological strength and technology development capability based on the above eight items, their values to Japan were converted into index numbers, using the corresponding values to the United States as the base values equalling 100. First, the average of the index numbers of 1)-4) was calculated as the index number representing Japan's technological strength. Next, the average of the above-mentioned average, the index numbers of 5)-6) for the investments in science and technology, and those of 7)-8) for the results achieved due to the technology development capability were calculated as the index number representing Japan's technology development capability. In Figure 1.1.20, the index numbers of major industrial countries calculated by the above method for the latter half of the 1960s, the first half of the 1970s, and the first half of the 1980s are compared.

According to Figure 1.1.20, while the index numbers representing Japan's technological strength and technology development capability have been growing year by year, those for West Germany and France declined in the first half of the 1980s after rising in the first half of the 1970s and those for Britain were nearly constant through both periods.

As shown in the figure, Japan, which was at the bottom among the five major industrial countries in both technological strength and technology development capability in the latter half of the 1960s, ranked third next to the United States and West Germany in the first half of the 1970s and overtook West Germany in the first half of the 1980s to reach second place next to the United States. Compared with its technological strength, its technology development capability still somewhat lags behind. However, rapid improvement appears to be taking place in this area, too.

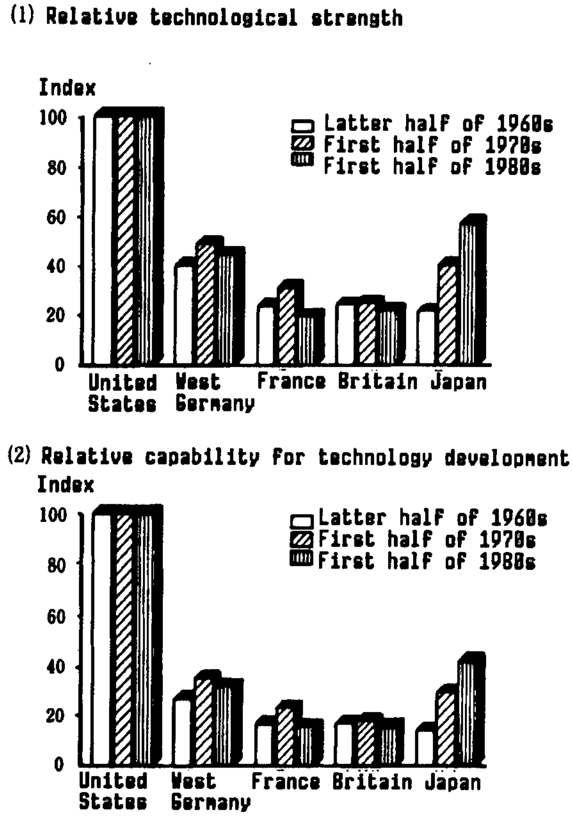


Figure 1.1.20. Change in Relative Technological Strength and Capability for Technology Development in Major Industrial Nations

Basis for Calculation of Relative Technological Strength and Relative Capability for Technological Development of Major Countries

Calculation of Relative Technological Strength

Here we have taken the scientific and technological strength contributing to the current productive capability to be the relative technological strength, then used that to try to make a quantitative comparison of the major advanced countries. It would appear that the asset approach is an indicator of relative technological strength. An international comparison has been made through a comprehensive evaluation of 1) number of patent applications; 2) amount of technology trade; 3) amount of export of technology intensive products; and 4) total amount of value added in the manufacturing industries.

First of all, it seems that the number of patent applications by persons within a given country is an indicator of the amount of technology currently contributing to that country's productive capability. Furthermore, in the case of patent applications to foreign countries by persons within a given country, as it can be said that application/registration is made for rather carefully selected items, it appears that the number of such registrations is an indicator of the

qualitative level of that country's technology. Then when one takes these two figures together as the total number of patent registrations, it serves as an indicator of that country's relative technological strength.

In addition, it also seems that the amount of technology exported (value received for technology exports) is one indicator of the quality of that country's technology. On the other hand, as technology imported from abroad is usually something of practical use, it would seem to be a major factor in directly raising that country's technological level, so taking that together with the amount of technology imported (value paid for technology imports) as the amount of technology trade, one has one indicator of that country's relative technological strength.

Then, using the strength that such technology is embodying in and bringing to actual industrial activity--in other words, as a comprehensive indicator of the size of the economic effects of such technology--we took the total value added amount of the manufacturing industries. Furthermore, we also used the amount of technology intensive products exported, which in particular seems to reflect the qualitative level of that technology.

Using these four indicators and letting the United States stand for 100, we calculated the indices for Japan, West Germany, Britain, and France for the last half of the 1960s, the first half of the 1970s, and the first half of the 1980s, performed simple averaging, and derived the overall technological level indices found in Table 1.

Calculation of Relative Capability for Technological Development

Here we took the ability for autonomous development of the new products and technology of the future to be the relative capability for technological development, making an international comparison similar to that of Table 1 by using 1) relative technological strength; 2) amount of R&D resources committed; and 3) R&D achievements.

First of all, a country's relative technological strength is an indication of the amount of technology accumulated by that country, which naturally has an impact on the capability for technological development, so it becomes one of the indicators used. Next, we took the research outlays and number of researchers as major resources used in the promotion of technological development, using a geometrical average of the two as one indicator of the amount of R&D resources committed. Finally, as it is possible to see how high technological development capabilities are by looking at the quality and quantity of R&D achievements, as indicators of that we have used the amount of technology exported and the number of patents acquired overseas, indexing them respectively and deriving a simple average of the two. Then by carrying out simple averaging of these three indicators, we have derived the overall index of capability for technological development shown in Table 2.

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Internationalization of Science and Technology

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[Text] **Section 1. Chapter 3. Present Situation of Internationalization Effort**

In the preceding chapters, how much the developments of science and technology in our country are related to the international economy and matters in international society, and how much they have gained importance in international politics has been described. At the same time, it has also been reported that the development of science and technology has been pushed under intensifying international competition, while maintaining international interdependence in these fields, in the age of growing need for more sophisticated science and technology.

By reviewing the progress in science and technology in foreign countries, it has been found that the United States still maintains a leadership position. However, this white paper pointed out the need to recognize the significant contributions of Japan and European countries to the developments in international science and technology.

Under these circumstances, it has now become urgent for Japan to promote internationalization of science and technology, in a manner commensurate with the country's present international position. The need for internationalization has been mounting in light of the country's strong economic power and the fact that R&D activities have greatly expanded in recent years. In this connection, it is necessary for us to note that with the increase of Japan's economic power, the developments in the country are increasingly affecting other countries.

In this chapter, the present situation of the internationalization of science and technology in Japan will be discussed mainly from the viewpoint of international exchanges.

A survey was carried out to find out the ides and attitudes of the private sector corporations toward internationalization, to help Japan play a greater role in the international community. Concerning the internationalization of R&D, many companies are considering dispatching their staffs to foreign research institutes to make use of foreign research facilities and step up research to produce internationally competitive results (Figure 1.3.1). Regarding the measures that Japan must take to promote internationalization, those firms surveyed stressed the importance of promoting the exchange of research personnel, generating useful technologies in basic high-tech sciences as internationally shareable assets, and improving domestic research institutes to make them more appealing to foreign researchers (Figure 1.3.2).

(1) International Joint Research

With the rapidly changing progress in science and technology, the growing scale and complexity of matters involved with science and technology, and

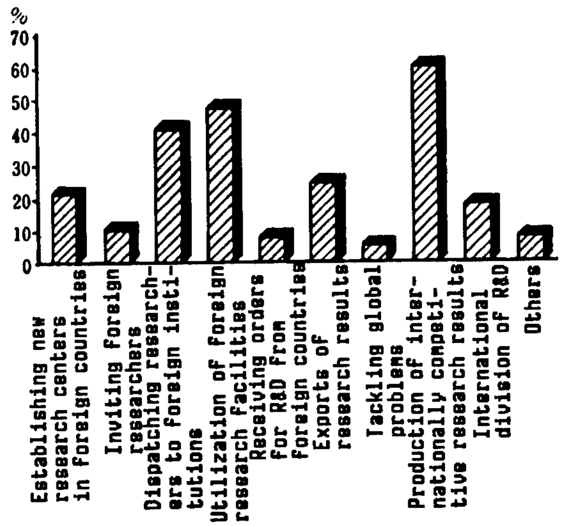


Figure 1.3.1. Steps Suggested by Private Japanese Companies to Internationalize Own R&D Activities

Source: Results of survey on research activities of private companies, conducted by Science and Technology Agency, 1987

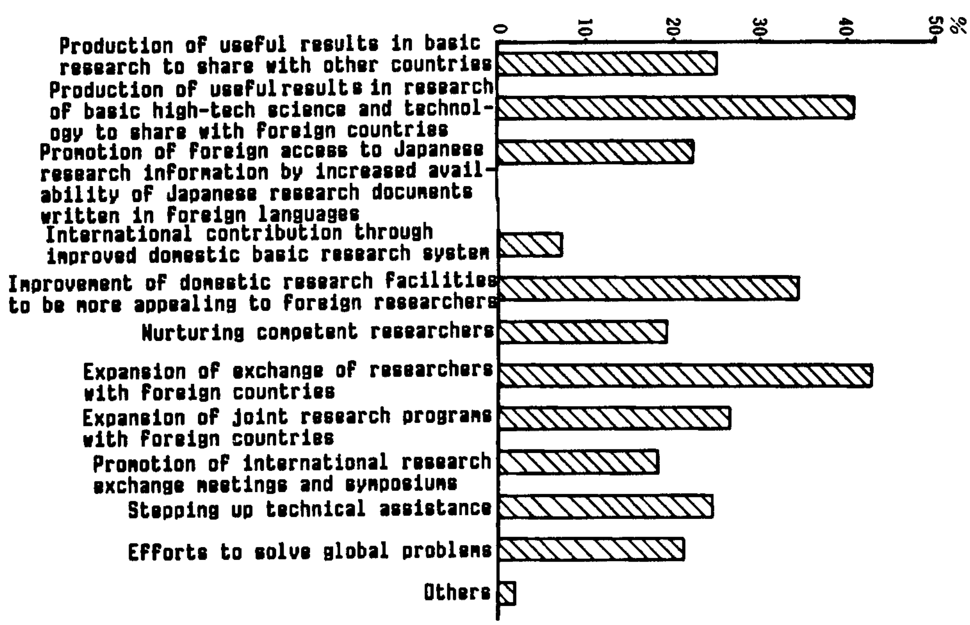


Figure 1.3.2. Policies Suggested by Private Companies for Japanese Government To Take To Internationalize Japan's Science and Technology

Source: Same as in Figure 1.3.1.

the increasing number of academic fields involved in such endeavors in recent years, the problems that must be tackled through international cooperation in R&D, and the problems that have global consequences, such as environmental problems, are increasing. It is important to promote international exchange of researchers to encourage international R&D, considering that the achievements in basic science and technology research are accumulated as common assets of mankind. Under these circumstances, international cooperation in the following fields has become essential.

1. Nuclear fusion, high energy physics, space development, and marine development: fields where R&D activities call for the use of special large-scale equipment and facilities.

Examples: Japan-U.S. science and technology cooperation, nuclear fusion, high energy physics, the space station program, and the international deep-sea drilling program (ODP).

2. The fields where problems must be tackled on a global scale, such as measures being taken against adverse climatic changes and desertification. Examples: the international research program against weather changes (WCRP), and international lithosphere exploration program (DELP).

3. The basic research fields that generate intellectual assets shared by mankind. Examples: Japan-U.S. science and technology cooperation and harnessing solar energy through photosynthesis.

4. The science and technology fields devoted to fighting diseases. Examples: Japan-U.S. research cooperation program against cancer and Japan-U.S. medical cooperation program.

Japan has been conducting R&D in these fields through bilateral and multilateral (regional cooperation and cooperation with international organizations) cooperation projects (Table 1.3.3). In recent years, Japan has signed international cooperation agreements in science and technology with India, South Korea, and Canada, and similar agreements are expected to be signed with more countries. This reflects the growing respect for Japan in science and technology research by foreign countries.

To promote such international cooperation, Japan has been pushing to sign bilateral agreements and cooperating with concerned international organizations.

The leaders of Western industrialized nations who gathered at the June 1982 Versailles summit agreed on the importance of international joint research in scientific fields. At the March 1983 meeting of the working group on science and technology, which was established in compliance with the summit declaration, 18 new science and technology cooperation projects were proposed. They include projects on solar power generation, photosynthesis, and the development of sophisticated industrial robots. Now R&D in these fields is underway through international cooperation. At the June 1980 Venice summit, Japan proposed the start of a "human frontier science program." The feasibility study for launching the program is now underway.

Table 1.3.3. Existing Frameworks for Promotion of International Cooperation in Science and Technology

Bilateral cooperation	S&T cooperation agreements: 13 countries; 14 accords	
Science and technology cooperation agreements (13 countries, 14 accords)	Japan-Soviet S&T cooperation agreement	(Oct 1973)
	Japan-France S&T cooperation agreement	(Jul 1974)
	Japan-Germany S&T cooperation agreement	(Oct 1974)
	Japan-Poland S&T cooperation agreement	(Nov 1978)
	Japan-U.S. energy cooperation agreement	(May 1979)
	Japan-U.S. nonenergy cooperation agreement	(May 1980)
	Japan-China S&T cooperation agreement	(May 1980)
	Japan-Australia S&T cooperation agreement	(Nov 1980)
	Japan-Indonesia S&T cooperation agreement	(Jan 1981)
	Japan-Yugoslavia S&T cooperation agreement	(May 1981)
	Japan-Brazil S&T cooperation agreement	(May 1984)
	Japan-India S&T cooperation agreement	(Nov 1985)
	Japan-S. Korea S&T cooperation agreement	(Dec 1985)
	Japan-Canada S&T cooperation agreement	(May 1986)

Multilateral cooperation		
Cooperation/international organizations	United Nations	Intergovernmental Committee for Development of Science and technology (ICSID) UN conference on new recycled energy Economic and Social Commission for Asia and the Pacific (ESCAP) UN Educational, Scientific, and Cultural Organization (UNESCO); Others
	OECD	Commission on Science and Technology Policy (CSTP) International Energy Agency (IEA) Others
	Others	Summit
Regional cooperation		Asian Scientific Cooperation Association (ASCA) Japan-ASEAN S&T cooperation

Source of material: Science and Technology Promotion Bureau of Science and Technology Agency

The Science and Technology Agency's survey of private sector companies found a tendency to put greater emphasis on international joint R&D among many of those surveyed. This tendency is particularly strong in the fields of life sciences, health/medical care, space, and the earth.

As the survey results suggest, Japan will be increasingly required to push basic research, the fruit of which will be shared as common assets of mankind, and tackle the problems that must be solved through global efforts to promote science and technology research activities through international cooperation.

(2) Improvement of Domestic Research System

As a result of the rapidly changing research environment and the spectacular advancement in science and technology in recent years, much research is being conducted beyond the border of a particular field. This situation makes it increasingly necessary for Japan to promote joint

research and exchange of research personnel with foreign countries and to upgrade the research system in the country.

1. To meet this need, a law designed to promote more efficient use of research facilities as well as research personnel and exchange of researchers among different institutions, particularly among national research institutions, was enacted 20 May 1986. This law opened the door of the national institutions to foreign researchers to conduct their research as a public institution employee, and made it possible for them to attend various scientific meetings in this country. The law is also designed to encourage the use of national research facilities and the patents obtained as a fruit of international joint research by offering them free of charge or at low cost.

Prior to the enactment of the law, the domestic national research institutions were already receiving foreign researchers for the purpose of training them or conducting joint research. This legislation prompted MITI's Agency of Industrial Science and Technology to invite British researchers to its Mechanical Engineering Laboratory in September 1987 to engage in research. The Science and Technology Agency followed suit by admitting American researchers to its National Research Institute for Metal in December of the same year. As seen in these examples, domestic research institutions began to consider receiving foreign researchers more positively since the law went into force.

Recognizing the importance of promoting exchange of research personnel between this country's governmental, industrial, and academic research institutions and their foreign counterparts, the following steps have been taken since before the enactment of the law.

--In FY 1981, a research promotion system was established to promote the search for and nurturing of seeds, which will be used to promote technological innovations, in which researchers from domestic government, industrial, and academic institutions and foreign countries participated. The system is run by the government Research Development Corporation of Japan. So far, 15 projects have been launched, among which 4 were completed in 1986 and 1 in 1987. Among 258 researchers who have participated in these projects, foreign researchers account for a little more than 10 percent with 32 coming from 15 countries.

--In FY 1986, the "international frontier research system" was launched by the Institute of Physical and Chemical Research aiming at unearthing completely novel ideas that would serve as the base in promoting technological innovations in the 21st century. This system is also intended to promote high-tech basic research in completely new fields systematically and on a long-term basis with the participation of researchers from various fields. The system opens the door to foreign researchers to participate. At present, 7 groups of researchers are engaged in research, and 16 foreign researchers are participating, 3 of them each heading a group.

Table 1.3.4. Changes in Number of Foreign National (Full-Time) Teachers in Japanese Universities and Colleges

	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
Number of teachers invited	1,255	1,285	1,376	1,436	1,516

Source: Results of Ministry of Education survey on Japanese schools

2. As shown in Table 1.3.4, the number of foreign teachers invited by Japanese colleges and universities has steadily increased in recent years. In recent years, these academic institutions have stepped up their efforts to promote international exchange of researchers. Some of these institutions promote exchanges under agreements with their foreign counterparts.

A special law governing the hiring of foreign instructors that was enacted 1 September 1982 allows this country's public colleges and universities to hire foreign teachers on a full-time basis.

Efforts are being made to promote joint research between national university and private sector organizations on a common theme, with the universities receiving research staff or financial support from the private organizations. In FY 1987, the research centers to promote this joint research were established in three state universities, including Toyama University in central Japan.

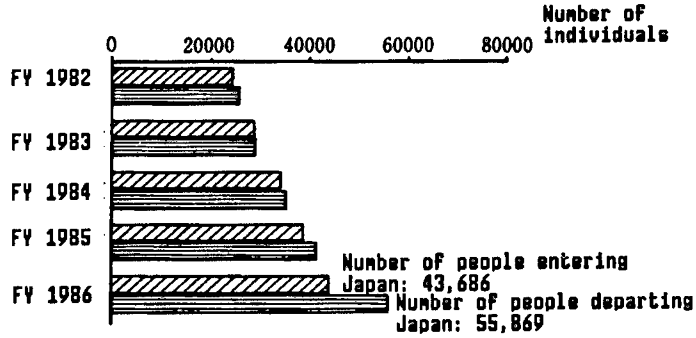
3. In addition to all these measures, the following have also been taken. They are the improvement of the international research exchange system by the concerned ministry and agencies, the establishment of new joint research centers by the government, the promotion of joint research on a specific theme between public and private institutions, the promotion of international joint research funded by state science and technology promotion funds, and the internationalization of research activities including exchange of research personnel.

(3) Exchange of Researchers

This section describes the present situation of the exchange of researchers with foreign countries as a barometer of the internationalization of research activities in this country.

1. Figure 1.3.5 shows the trend in the number of science and technology related individuals who entered or departed Japan in the past 5 years (source of data: immigration control statistics by Ministry of Justice).

According to the figure, the number of foreigners who came to Japan for the purposes of study, training, teaching, academic and cultural activities, and technical cooperation registered a 1.8 increase from 24,270 in 1982 to 43,686 in 1986.



Source of data: Immigration control annual report compiled by Ministry of Justice

Figure 1.3.5. Trend in Number of Science and Technology Related Individuals Either Entering or Departing Japan, as Reported by Japanese Immigration Authorities

On the other hand, the number of Japanese who went to foreign countries for study, acquiring new technologies, and academic research and investigation recorded a 2.2 increase over the same period from 25,727 to 55,869.

Figure 1.3.6 shows the trends in the number of science and technology related individuals entering or departing Japan.

Regarding nationality of those who entered Japan, those from Asian countries have accounted for more than 70 percent since 1982, and the percentage continues to increase. This is followed by North America, accounting for about 10 percent. On the other hand, as for the destination of Japanese engineers and researchers, North America is most popular, with more than 50 percent heading there since 1982. North America is followed by Europe and Asia in that order.

From Figure 1.3.6 it can be seen that the number of Japanese departing Japan is higher than the number of foreign nationals entering the country, as far as the figures in the 5-year period since 1982 is concerned. However, it can be said that the number of departures and arrivals are almost balanced. But by region, the number of Asian nationals entering Japan far surpasses Japanese nationals departing for that region, while the number of Japanese departing for Europe and the United States far exceeds nationals coming from these Western countries.

2. Figure 1.3.7 gives the number of researchers exchanged under the auspices of the Japan Society for the Promotion of Science (JSPS), with the exchange centering on universities.

The number of foreign nationals entering Japan has been on the increase, though not significantly, in recent years. By region, Asians topped the list accounting for 50 percent of the total in FY 1986, followed by Europeans (27.2 percent), and North Americans (12.3 percent). In FY 1986, North America was the most popular destination for Japanese science and technology related personnel, with 43 percent of those departing Japan that

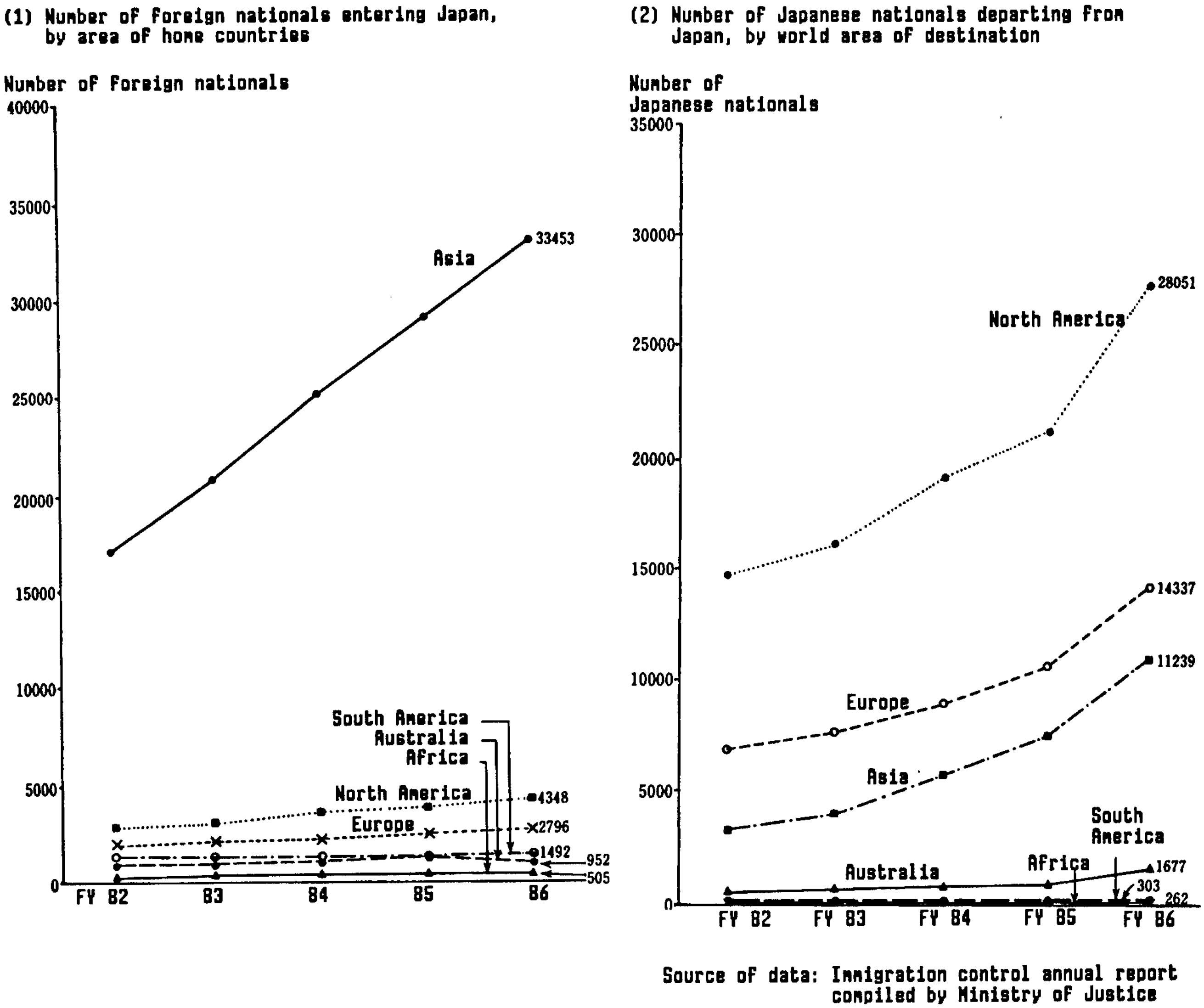


Figure 1.3.6. Trend in Number of Science and Technology Related Individuals Either Entering or Departing Japan, by World Area

year going to the region. North America was followed by Asia (36 percent) and Europe 18.3 percent). Regarding the numbers of foreign nationals coming to Japan and Japanese nationals going abroad, the same trend as discussed in item 1 can be seen. Among those entering Japan, Asian nationals predominate and North America is the most popular destination for Japanese nationals.

3. Figure 1.3.8 shows the trend in the exchange of research personnel with foreign countries by Japan's private companies.

Regarding the number of foreign nationals accepted by the private companies, East and Southeast Asia ranked first, accounting for 51 percent

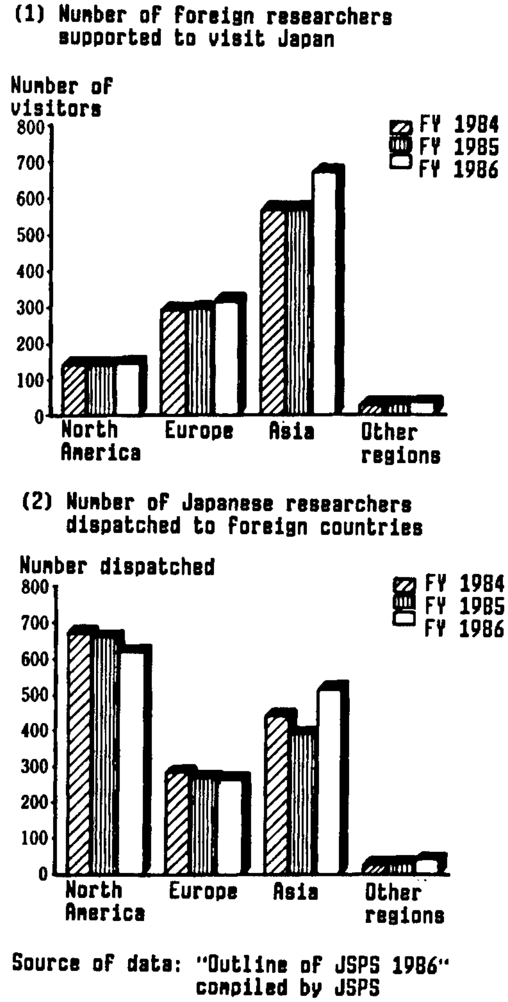
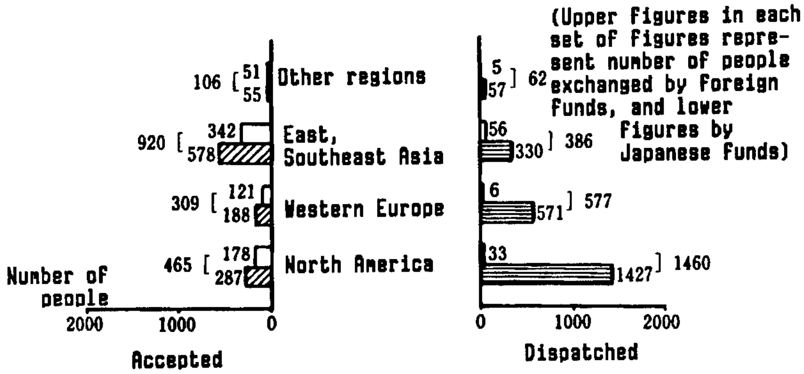


Figure 1.3.7. Number of Researchers Exchanged Under Auspices of Japan Society for the Promotion of Science (JSPS)

of the total received in FY 1987. They were followed by researchers from North America and Europe. As for the destination of Japanese researchers, 59 percent went to North America, followed by those going to Europe and East and Southeast Asia in that order. Even in the private industry, Asians predominated the foreign researchers coming to Japan, and North America proved the most popular destination for Japanese researchers, the same trend as discussed in item 1.

The purpose of Japanese private companies for receiving foreign researchers is to give training and exchange information and technical cooperation, in that order.



Source of data: Results of an FY 1987 survey on research activities of private companies, conducted by the Science and Technology Agency

Figure 1.3.8. Numbers of Researchers in Private Industry Exchanged With Foreign Countries

4. Following are the principal government-backed systems being run to promote the invitation of foreign researchers in science and technology fields to Japan.

i) Systems run by the Science and Technology Agency: system for inviting foreign researchers in science and technology fields, exchange system for nuclear research, foreign engineer invitation system managed by the space development committee, and science and technology promotion fund (for promoting basic research in specific fields, important international joint research).

ii) Systems run by MITI's Agency of Industrial Science and Technology: invitation of research managers, special researchers, and joint program researchers under the international industrial technology research project; and international research cooperation Japan trust project.

iii) Systems run by the Ministry of Education: invitation of foreign researchers, and JSPS-managed foreign research invitation program.

iv) Systems run by the Ministry of Agriculture, Forestry and Fisheries: invitation of research managers by the Ministry's Tropical Agriculture Research Center, and invitation of joint program researchers.

v) Systems run by the Ministry of Posts and Telecommunications: foreign researcher invitation program and others.

5. A survey found that the most important problem that must be tackled in inviting foreign researchers to this country is to secure adequate living environments for them (Figure 1.3.9).

To deal with this problem, the government completed the construction of dormitories for foreign researchers in Tsukuba academic town near Tokyo in

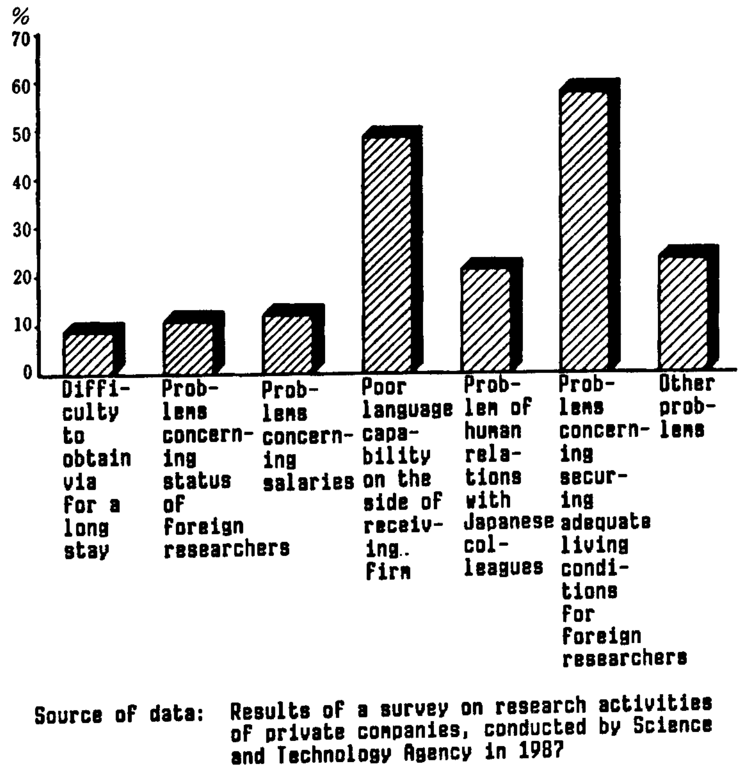


Figure 1.3.9. Problems Encountered by Private Companies in Receiving Foreign Researchers

September 1987. The dorms were built to encourage foreign researchers to work at the national research institutions. Some national universities here have already been building similar lodging facilities for foreign researchers since around 1966. In private industry, similar efforts have been made, including offering the dormitories for single employees and renting apartments for those researchers.

The improvement of the environments for promoting international exchange of researchers concerns not only research environment problems but also living environment and language problems. These are not peculiar to international exchanges in science and technology. Considering this fact, it is necessary for Japan to promote the internationalization of society, in addition to efforts to internationalize science and technology.

(4) Information Exchange

With such an advancement of science and technology in Japan in recent years, the need of foreign countries to obtain information about the developments in the country have been mounting. Under these circumstances, Japan is increasingly required to make information available to foreign countries, as part of its efforts to internationalize the country's science and technology, in addition to promoting exchange of researchers.

In this section, the present situation of the exchange of information by the national research institutions and private companies in Japan will be discussed.

1. First, the efforts that have been made so far will be reviewed by introducing the work pushed by the national research laboratories under the jurisdiction of the Science and Technology Agency. The following discussion is based on the results of related surveys conducted by the agency.

Among the 11 research institutions, 4 distribute information on research results to a number of foreign institutions on a regular basis. The rest give information only when they receive requests from foreign countries.

Among the publications carrying research results that were published in FY 1986 about 70 percent were written in foreign languages. As for the region to which these publications were mailed, 60 percent were sent to Europe, followed by North America (24 percent). Fifty-five percent of those publications mailed abroad were sent to government organizations, followed by universities with 31 percent (Figure 1.3.10). These publications contained a total of 1,256 articles, 60 percent written in foreign languages.

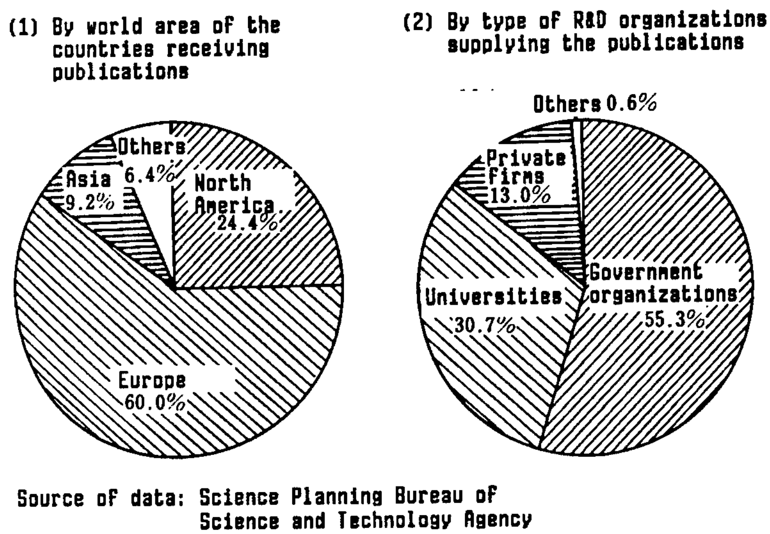
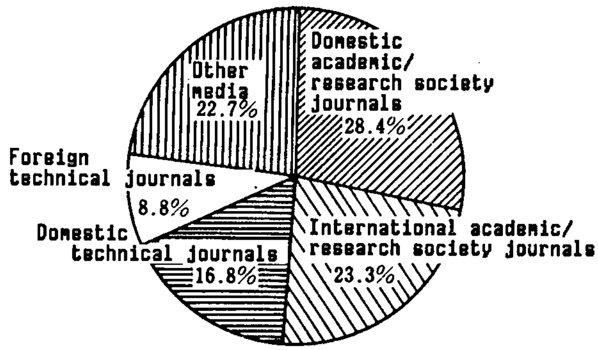


Figure 1.3.10. Destinations of Research-Related Papers or Publications Distributed or Provided by Japanese R&D Organizations to Foreign Countries

As for the media through which researchers disseminate their research results, most use technical journals or publications were written in foreign languages (Figure 1.3.11).

2. Figure 1.3.12 shows the present situation and problems encountered in technical information exchanges by private companies.



Source of data: Science Policy Bureau of Science and Technology Agency

Figure 1.3.11. Media Used by Research Organizations for Disseminating Information on Individual Research Results

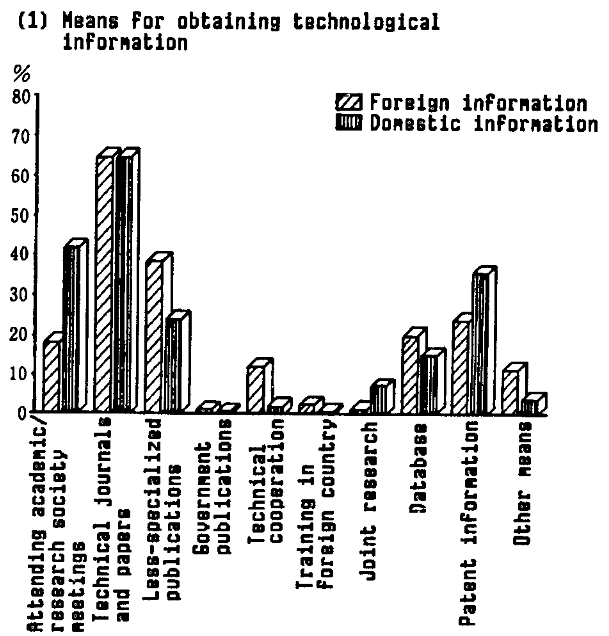
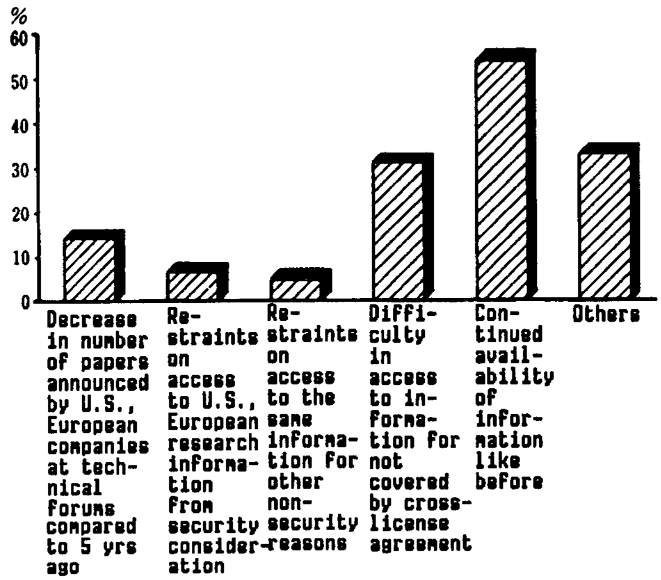
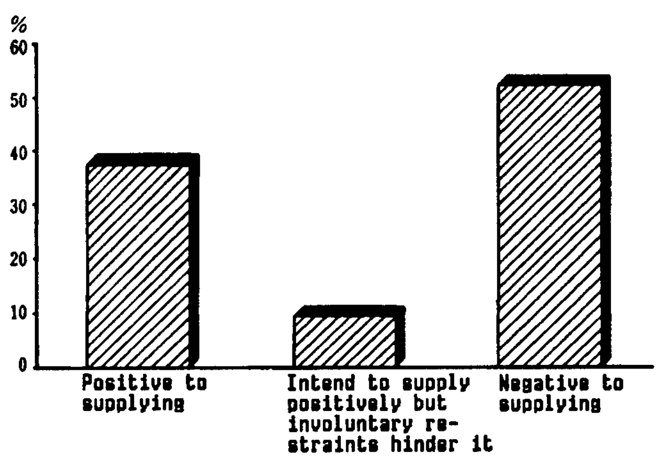


Figure 1.3.12. Present Situation of Technological Exchanges by Private Companies [continued]

(2) Restraints in obtaining overseas technological information



(3) Attitudes of private companies toward supplying information to overseas



Source of data: Results of a survey on research activities of private companies, conducted by Science and Technology Agency in 1987

[Continuation of Figure 1.3.12]

As for the means through which the private companies obtain foreign technical information, they rely primarily on technical journals and papers published in Japan and foreign countries. They also obtain information through other less-specialized publications and patent information. They obtain domestic technical information primarily through the technical journals and papers published within this country. The information is also obtained by attending meetings of academic/research societies and, although less dependent on it, through patent information.

Concerning the possible restraints in obtaining technical information from foreign countries, the largest number of companies surveyed answered that they had experienced no particular difficulties. However, about one-third of the companies recognized the necessity to help foreign countries obtain Japanese technical information, such as through a cross-license agreement. This survey suggests the necessity for a private company here to be equipped with its own technology that it can give to a foreign country when it obtains technical information from the country.

In Japan, some of the technical information, held by a private company as a private asset, is already accessible to foreign countries as patent information, in case the technology involved is patented. A survey found that a little more than 40 percent of private companies covered in the survey was positive about supplying their technical information to foreign countries, but more than 50 percent responded negatively.

3. In Japan, the Japan Information Center of Science and Technology (JICST) plays the central role in collecting science and technology related information from around the world. The amount of information collected by the center in FY 1986 reached 520,000 items that were put in the center's database after the necessary processing. The center also provides on-line information service using this database to domestic customers. To meet demand from foreign countries, the center started translating domestically collected information and materials into English in FY 1985. In FY 1986, JICST began providing English database service along with Japanese database service. As of August 1987, the center distributes science and technology information on-line to seven countries--the United States, West Germany, France, England, Canada, Finland, and South Korea.

In FY 1986, JICST signed agreements with Chemical Abstract Service of the United States and Fitz Karlsruhe of West Germany for the joint construction and operation of an international on-line science and technology information network (STN international). This is a tripartite international project between Japan, the United States, and West Germany, and the service was to start in 1987. With the start of this service, it will become easier for Japanese researchers to access science and technology information held by the United States and European countries, and for researchers in these foreign countries to use Japanese science and technology information. This service will lead to promoting international distribution of information.

JICST is also providing information on energy and agriculture to the countries affiliated with the Asian Science Cooperation Association (ASCA), by translating abstracts of Japanese materials in these fields into English, to promote science and technology cooperation programs for these countries.

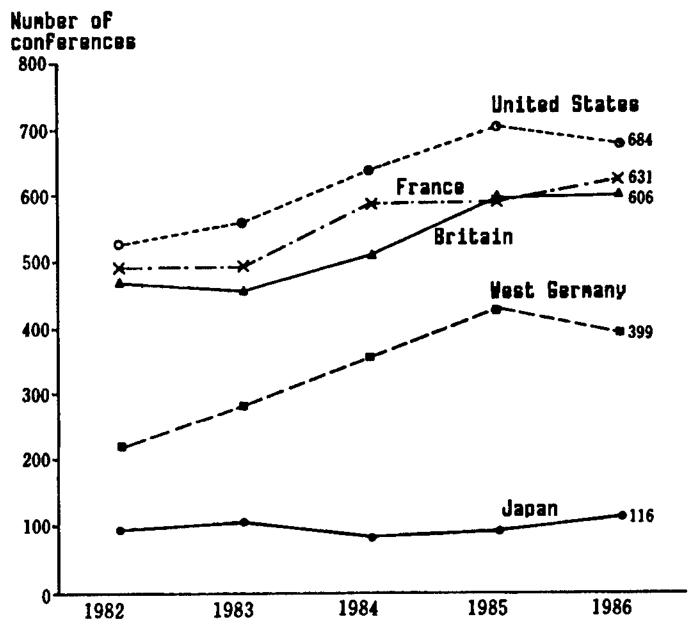
As for the 520,000 science and technology research documents produced by Japanese researchers that were processed by JICST and added to the database in FY 1986, 11.7 percent were written in English. This compares with 9.7 percent in FY 1985.

To facilitate building an English database for foreign users, JICST has embarked on the development of a practical, serviceable computer translation system.

(5) Holding an International Convention in Japan

The number of international conferences held can also be taken as an indicator of the degree of internationalization of science and technology of a country. In this section, the international conferences held in Japan and other major industrialized countries will be reviewed.

1. According to the statistics compiled by the international organizations federation (UAI), the number of international gatherings held in major industrialized countries have increased in general in recent years (Figure 1.3.13).

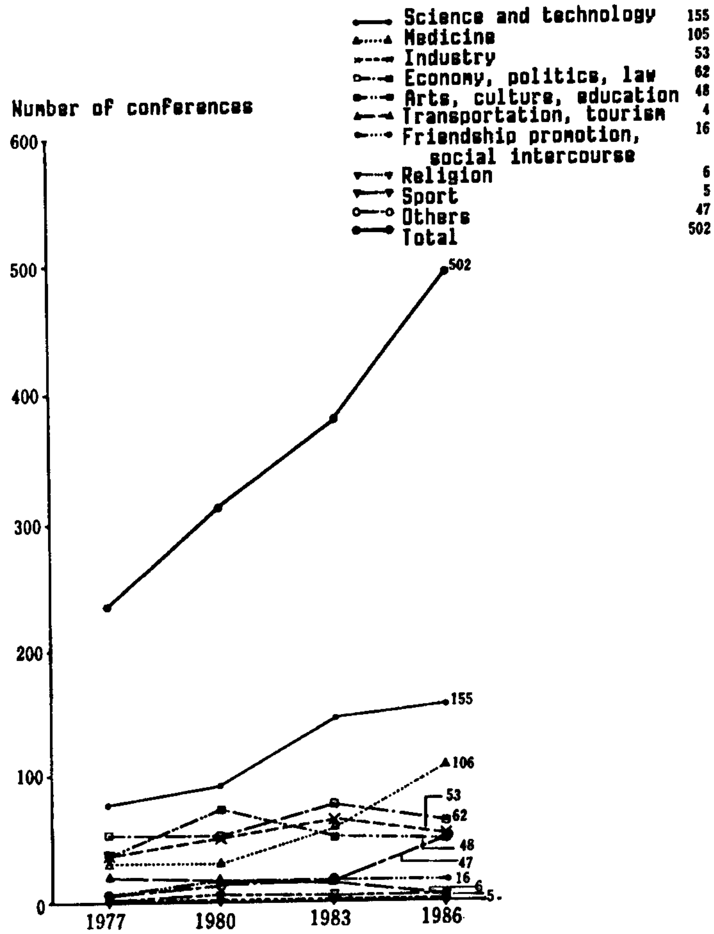


Source of data: Statistics compiled by the international organization federation (UAI)
Source of material: "1986 Convention Statistics" compiled by the Japan National Tourist Organization

Figure 1.3.13. Changes in Number of International Conferences Held in Major Industrial Nations

The number of international conferences held in Japan is smallest among the major industrialized democracies, partly due to the geographical separation from the Western countries.

2. On the other hand, according to the statistics compiled by the Japan National Tourist Organization (JNTO), the number of international meetings held in Japan more than doubled over a 10-year period between 1977 and 1986, increasing from 236 in 1977 to 502 in 1986 (Figure 1.3.14).



Source of material: "1986 Convention Statistics" compiled by JNTO

Note: UAI defines an international conference as "a gathering of international organizations with the participants representing more than three countries." While the definition by JNTO states an international conference is "a gathering, symposium or seminar in which people from more than two countries participate." This difference of definition causes a significant gap between the number of international conferences tabulated under the UAI definition and the number counted under the JNTO definition.

Figure 1.3.14. Changes in Number of International Conferences Held in Japan, by Field

On the other hand, by field, the number of international conferences on science and technology has continued to increase every year. In 1986, such conferences accounted for 30.9 percent of the total international gatherings held that year, with 155 science and technology related conferences held. Next followed conferences on medicine with 106 (21.2 percent) held, and the conferences on economics, politics, and law with 62 (12.3 percent) held. Conferences in science/technology and medicine combined accounted for more than 50 percent (261) of the international conferences held in 1986.

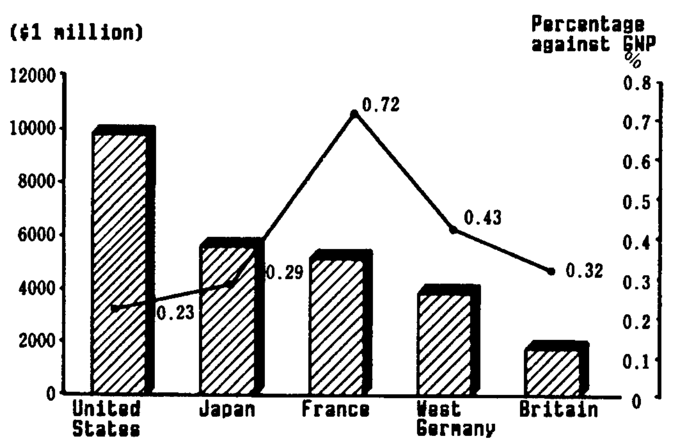
(6) Cooperation to Developing Nations

As part of the international cooperation, Japan has been extending various forms of cooperation in the fields of economics, science and technology to developing countries.

By recognizing the importance of increasing economic assistance to developing nations as its responsibility in international society, Japan has been making efforts to expand assistance by revising the targets of its official development aid (ODA) to developing countries three times since 1978. And in the emergency economic policy announced on 29 May 1987, the government, in connection with the third medium range ODA target, decided to move up the original target of 7 years by 2 years, doubling the amount of ODA, considering Japan's increasing power in the world economy and the abrupt change in the international environment regarding Japan in recent years. This requires Japan to increase the amount of ODA to more than $7.6 billion in 1990.

In the following, Japan's international cooperation to developing countries in recent years will be reviewed using various data.

1. Figure 1.3.15 gives the amounts of ODA extended to developing countries by major Western industrialized democracies in 1986. The statistics were compiled by the Organization for Economic Cooperation and Development (OECD)/Development Assistance Committee (DAC).



Source of material: "International Cooperation Annual Report" compiled by Japan International Cooperation Agency (JICA)

Figure 1.3.15. Amounts of ODA Extended by Major Western Industrialized Democracies in 1986, and Percentage of Amounts Against GNP of These Countries

According to the figure, the United States topped the list in ODA amounts extended that year with $9.784 billion, followed by Japan ($5.634 billion) and France ($5.136 billion). In terms of the percentage of these amounts against the GNP of these countries, France was on top with 0.72 percent,

followed by West Germany (0.43 percent), England (0.32 percent), and Japan (0.29 percent).

2. Technical cooperation to developing countries constitutes part of the economic cooperation, and is being carried out by either receiving people from these countries to give them necessary training so that they can play leading roles in their countries' economy and social development in the future, or by dispatching experts to these countries. The benefit of this cooperation is significant in that it promotes mutual understanding through person-to-person contact. In Japan, international technical cooperation is managed mainly by JICA, with cooperation from related government ministries and agencies.

With the advancement of the ODA schedules, Japan's technical cooperation in terms of the DAC values has increased in recent years. In 1986, the value of the cooperation in the form of equipment, research assistance, and other associated assistance came to $341.9 million, accounting for the largest percentage (40.3 percent) of ODA funds. For the dispatch of experts, the value came to $277.8 million (32.7 percent), followed by $133.8 million (15.8 percent) for accommodating trainees from foreign countries, $59.8 million (percent) for accommodating foreign nationals studying here, and $35.4 million (4.2 percent) for dispatching young Japanese to developing countries to help local people in various kinds of projects (Figure 1.3.16).

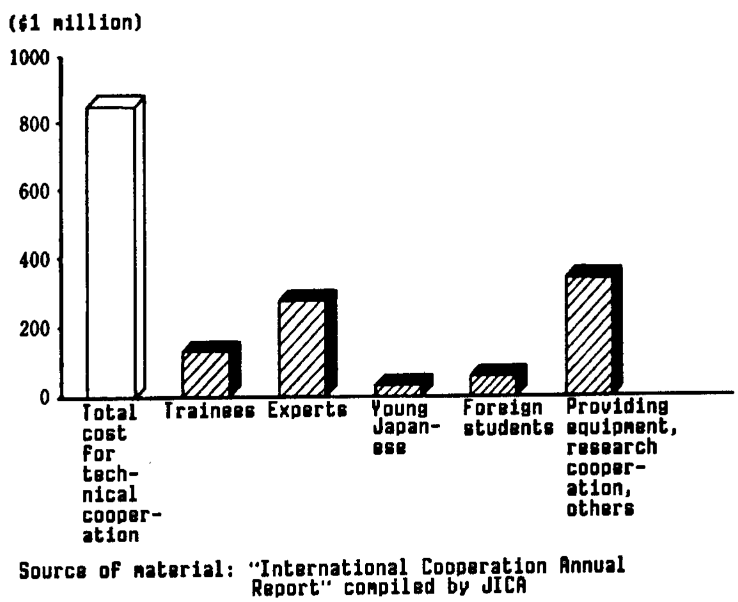


Figure 1.3.16. Technical Cooperation Extended by Japan in 1986 Under Auspices of OECD's Development Assistance Committee

Regarding the accommodation of trainees from foreign countries, their number as of 1986--combining those newly received in that year and those who had been undergoing training from preceding years--totaled 6,714,

according to JICA statistics. By region, the largest number came from Asia, followed by Central and South America, Africa, and the Middle and Near East. By field, the largest number came from the field of public works, followed by human resources, and agriculture, forestry, and fisheries (Figure 1.3.17).

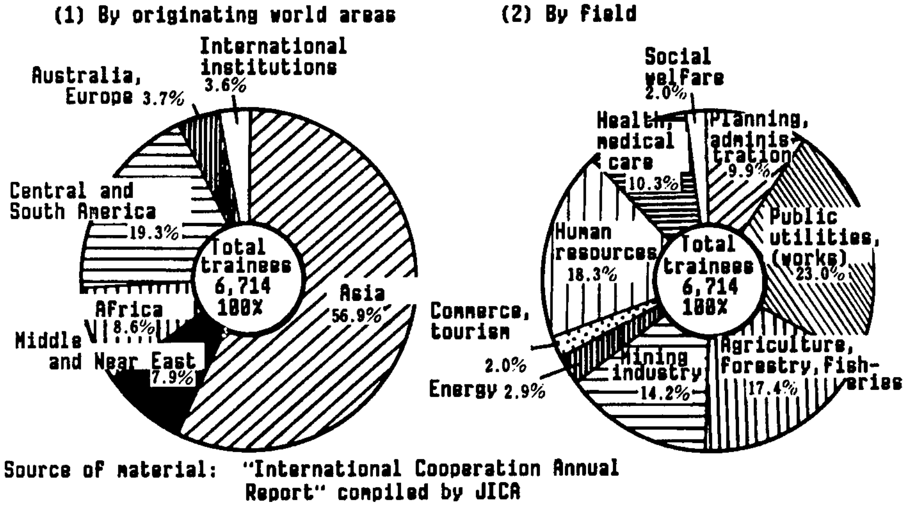


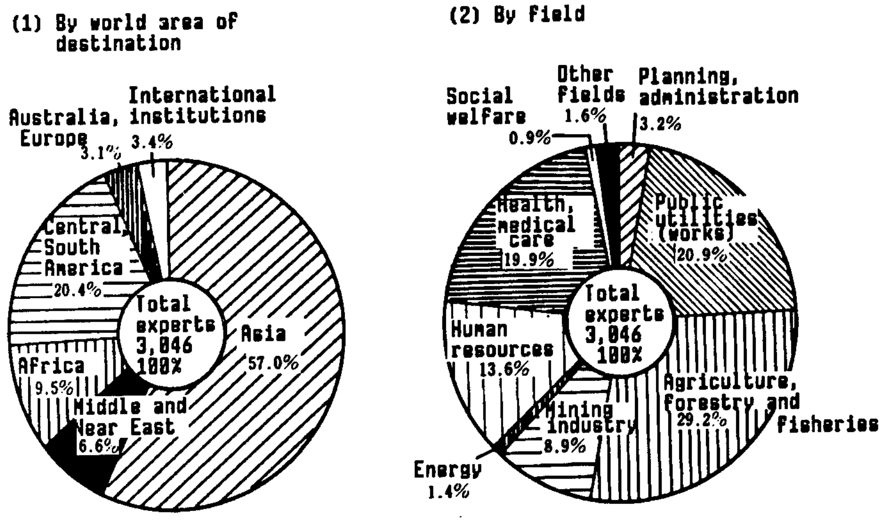
Figure 1.3.17. Percentage Distribution of Trainees Received From Foreign Countries in FY 1986 Against Total Number

As of 1986 the number of Japanese experts dispatched was 3,046, with those who were newly dispatched in that year and those who had already been active for some time in foreign countries combined. By region, the largest number was dispatched to Asia, followed by the Middle and Near East, and Africa. By field, the largest number went to the fields of agriculture, forestry, and fisheries, followed by public works, and health and medical care (Figure 1.3.18).

By region from which trainees are received or to which Japanese experts are dispatched, Asia far exceeds other regions in the number of people involved. By field which Japanese experts represent, public utilities, other public businesses, and agriculture, forestry and fisheries combined ranked first.

3. Table 1.3.19 gives a comparison of the numbers of these trainees and experts among a number of major industrialized countries.

According to the table, the United States ranked first in the number of trainees and foreign students received and experts dispatched, followed by Japan, England, and West Germany, in that order. In the number of trainees and foreign students combined, Japan was ahead of other countries, particularly in the number of trainees. While in the number of experts dispatched, the United States outdistanced other countries, and was followed by Japan. In the number of volunteers, Japan dispatched a relatively small number compared to the number of experts and investigation delegations it dispatched.



Source of material: "International Cooperation Annual Report" compiled by JICA

Figure 1.3.18. Percentage Distribution of Japanese Experts Dispatched to Foreign Countries in FY 1986 by Region They Were Dispatched to and Field They Represent

Table 1.3.19. Comparison of Technical Cooperation of Major Industrialized Nations to Developing Nations in the Form of Receiving Trainees or Dispatching Experts in FY 1984

Category	Japan	U.S.	Britain	West Germany
1. Foreign students, trainees	15,460	10,846	13,515	12,101
Foreign students	2,820	4,879	8,588	4,247
Trainees	12,640	5,967	4,927	7,854
2. Dispatching of experts, etc.	12,721	19,771	5,364	5,827
Experts, investigation delegations	11,046	15,072	3,715	4,213
Volunteers	1,675	4,699	1,649	1,614
Total	28,181	30,617	18,879	17,928

Figures represent the number of people involved.
Source of data: DAC statistics.
Source of material: "Japan's Diplomacy 1986," Ministry of Foreign Affairs

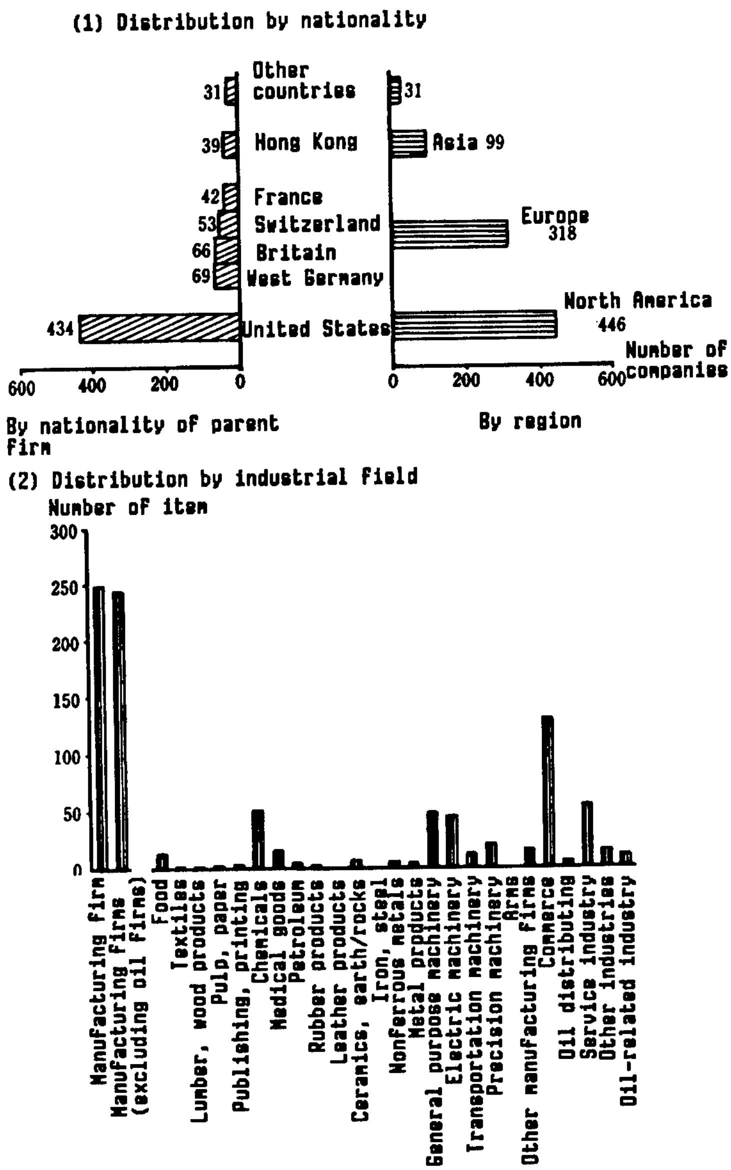
4. As for cooperation with developing nations in academic research, it is being extended to ASEAN nations by the Japan Society for the Promotion of Science. The cooperation is in the form of exchange of personnel between universities and assistance to those wanting to obtain a doctorate. the number of researchers exchanged between Japan and ASEAN nations under the

cooperation programs in FY 1986 was about 360 dispatched and about 390 received.

(7) Expansion of Foreign Operations by Business Companies

1. Advancement of foreign companies into Japan

With the growing economic power and rapid progress in the fields of science and technology in Japan in recent years, the number of foreign companies advancing into the country is increasing.



Source of data: Results of 19th survey on foreign capital companies in Japan conducted by MITI

Figure 1.3.20. Foreign Capital Enterprises Operating in Japan

Following are the results of the 19th survey on these foreign companies conducted by the Ministry of International Trade and Industry. The survey covered 2,094 companies in Japan having foreign capital higher than 50 percent, and valid answers were obtained from 894 firms. Of these 894 firms, 48.5 percent have U.S. corporations as their parent companies, 7.7 percent West German firms, 7.4 percent British companies, and 4.9 percent Swiss companies. The percentage of these European companies totaled 35.6 percent and Asian firms 11.1 percent. By category, 45.7 percent are manufacturing companies. Among these manufacturing companies, the largest percentage produce general purpose machinery, followed by firms producing chemical goods and those making electric machinery (Figure 1.3.20).

As of July 1987, the number of companies that were operating or scheduled to start operations in Tsukuba, where a university and many national research institutions are located, stood at 120, according to a Science and Technology Agency survey. Of these firms, about 10 percent (11 firms) are foreign capital companies and about 70 percent (85 firms) are conducting or scheduled to start R&D in the town. As for the 11 foreign capital companies, 8 are conducting or scheduled to start R&D there. The 11 comprise 8 U.S. firms, 2 French firms, and 1 British firm. Most of these companies are in the electronic communications and electrical measurement instruments business or the chemical business.

2. Advancement of Japanese firms to foreign companies

In the following the attitudes of Japanese companies toward overseas operations will be described (Figure 1.3.21).

According to the figure, half of those companies covered by the Science and Technology Agency survey already have manufacturing facilities in foreign countries. Two-thirds answered that they intend to further expand foreign operations. Two-thirds which have no production facilities overseas answered that they will continue to remain within Japan.

As for foreign R&D centers, 16 percent of those surveyed already have centers, and 12 percent intend to open R&D centers overseas in the future.

Concerning the establishment of R&D centers overseas, 62 percent of the companies surveyed said that they have no particular objection to moving part of the R&D operations to foreign countries. This was followed by 17 percent which were completely against moving even part of the R&D operations to foreign countries, and 11 percent which were very positive about moving overseas.

Sixty percent of the companies surveyed also said that they anticipated no significant adverse affects in the continuity of domestic technology, as a result of moving production operations to foreign countries. This indicates that they think a company's shifting operation to a foreign country would not necessarily lead to the degeneration of the company's R&D activities. Rather they seem ready to deal with the urge to shift part of their R&D operations to foreign countries positively, by maintaining the main center of R&D within Japan.

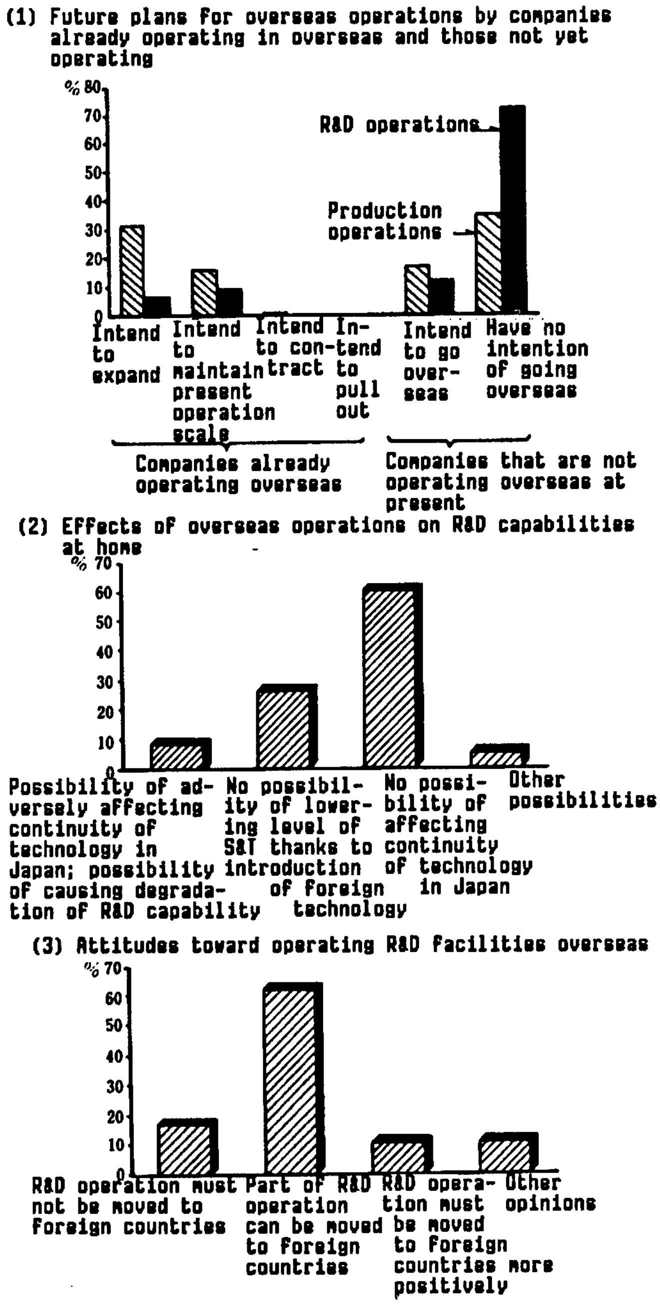
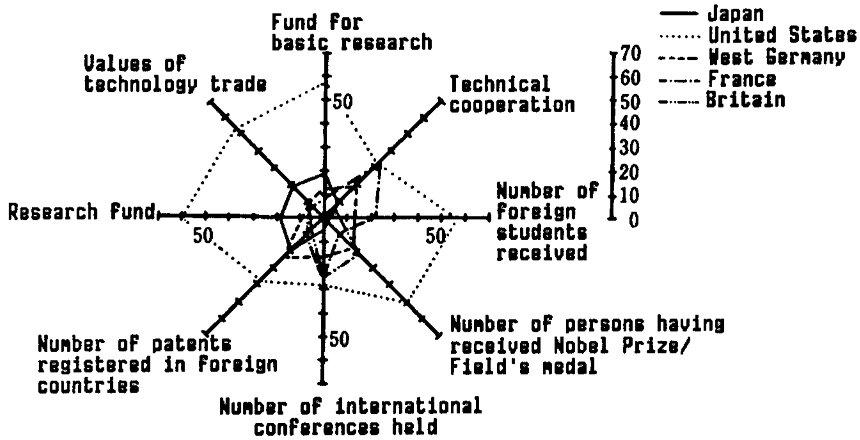


Figure 1.3.21. Attitudes of Japanese Companies Toward Overseas Operations and Their Plans for the Future

Source of material: "Results of a Survey on R&D of Private Companies (FY 1987)," Science and Technology Agency

(8) Conclusion

In this section, a comparison of the present situation of internationalization of science and technology in some major industrialized



Note: Indices for each country were calculated by assuming the total of Japan, United States, West Germany, France, and Britain as 100

Figure 1.3.22. Comparison of Science and Technology Related Indices Among Some Major Industrialized Nations for First Half of 1980's

countries will be made using science and technology related indices (Figure 1.3.22).

From the figure, it is apparent that the United States dominates the four other countries in all the indices. Each of these four countries has a strong point, but in general little difference in the indices can be observed.

By closely reviewing the present situation in Japan for promoting internationalization of science and technology, it becomes clear that although there exist various systems for this, they do not function satisfactorily. Under these circumstances, stepped up efforts must be made to promote basic research for generation of internationally useful results, produce competent researchers, and promote international exchange of information and researchers.

Chapter 4: Problems and Outlook of Internationalization Efforts

In this chapter, the problems and outlook in Japan's efforts to internationalize its science and technology will be discussed, to summarize what has been discussed in this white paper.

1. Boosting Level of Science and Technology

One of the tasks Japan must tackle in its effort to internationalize the country's science and technology is to enhance the level of science and technology to a point where foreign researchers will want to come to Japan to do their research. To realize this, Japan must further step up basic research. As described in the preceding chapters, the important thing in

Japan's effort to internationalize its science and technology is to produce research results that are highly evaluated internationally. The results of the surveys on the research activities of private Japanese companies conducted by the government reiterate this. MIT Professor Susumu Tonegawa winning the Nobel Prize in medicine/physiology and being the first Japanese to receive the prize is noteworthy because his achievements were recognized internationally as those produced by a Japanese researcher. But for Japan to be truly regarded as an internationalized country in science and technology, further efforts must be made to attract foreign researchers to this country to pursue their research, and help produce internationally significant results that may win a Nobel Prize.

For Japan to be recognized for its contribution to the progress of international science and technology, it is important to step up efforts to produce useful basic research results that can be shared with other countries. In recent years, efforts have been made in Japan to beef up the system to promote basic research. Among the private companies, a move to have them step up R&D on their own is mounting, starting with basic research. Today, there is increased need to strengthen basic and pioneering research whose results can be shared with other countries. To promote such research, a [government] science and technology advisory council issued a recommendation on the medium- and long-term goals of national research institutions in August 1987. Now these national research institutions are required to step up basic and pioneering research activities more effectively and efficiently, aiming at generating new technologies, in line with the recommendation. As for universities which play the central role in basic research, various measures must be introduced to encourage them to push original and pioneering research in line with the recommendations of the prime minister's advisory council on education and the 6 October 1987 Cabinet decision. The Cabinet decision concerns the concrete measures that must be taken to revise the country's education system. The private companies are encouraged to invest more money to promote basic research. At the same time, the government is required to appropriate more money for basic research at national research institutions. In addition, the important thing is to further strengthen cooperation between industry, academic institutions, and national research institutions, and promote joint research among them.

The international joint research program--the number of such programs having increased in recent years--is aimed at tackling common international problems using the advanced science and technology of the participating countries. The promotion of international joint research is considered to be of great benefit to enhancing the level of science and technology in Japan. At present, Japan is participating in many international joint research projects. It is required to play a larger role for the benefit of the international joint program while trying to further expand the joint efforts.

For this country's science and technology to become highly evaluated internationally, it is particularly important to encourage original basic research by improving research environments. In the United States and European countries--countries which have a long tradition of

individualism--environments have existed that enable original research results to be born, as a result of brisk dialogue and conflicts between different personalities. Now Japan must make efforts to generate what it has been unable to in the past, by nurturing cooperative and, at times, competitive research environments by increasing contacts with different personalities through stepped-up exchange of researchers with foreign countries.

The culture of this country, including science and technology, can be regarded as an all-embracing one, a culture that was formed as a result of fusion between the cultures of the East and West. The culture is based on the Oriental philosophy that values the hole, not the individual. In the effort to internationalize this country's science and technology, it is important to make stepped-up efforts to contribute to the science and technology of the world, by promoting the development of the science and technology based on the Oriental philosophy, through increased contacts with foreign science and culture.

In this connection, it is important to establish and operate the research evaluation system having the effectiveness, durability, flexibility, and the clarity of goal suitable for nurturing the buds of originality in research.

2. Establishment of Research Promotion System

To internationalize the science and technology of Japan, it is necessary first of all to enhance the level to the point where it is highly evaluated internationally. To realize this, it is necessary to establish the research promotion system suitable for the present internationalization efforts.

At present, in Japan various measures are being pushed to make the research system more open to researchers from other fields and foreign countries. To receive researchers from outside organizations or promote their exchanges, progress is being made in operating the research system where more and more researchers are freed from the bond of a particular research group. This trend is accelerating with the increasing sophistication of R&D endeavors and the increasing number of research programs that call for participation of researchers from different fields. In FY 1986, a domestic law aimed at promoting exchange of researchers was enacted. This increased the chance for foreign researchers to be hired by the national research institutions as regular staff members. As for the exchange of information, the publication of research results at the universities and national research institutions has been pushed more actively in recent years. In addition, other measures, such as Japan's participation in creating international information networks and building an English-language database, have been implemented to promote information exchanges.

As described so far, basically the research system in the fields of science and technology in Japan has already been open to a certain degree to foreign countries for some time. Despite this, various measures are being

implemented at present to promote the internationalization still further, and such efforts must be continued.

To speed up the internationalization, promoting international exchange of researchers is very important. Usually, in the fields of science and technology, a researcher decides to go to a foreign country when he is attracted by that country's high level of science and technology and wants to study and do research there. At present, the situation in international exchange depends largely on an individual researcher's wish to go abroad for study and research. The fact that the number of Japanese researchers going to the United States and Europe is larger than the number of researchers Japan receives from these Western countries indicates that Japanese researchers regard the standards of the science and technology of the Western countries higher than that of Japan. Among those Japanese researchers, there are a number, internationally recognized for their achievements, who continue to do research in foreign countries. This causes the so-called brain drain problem for Japan. It can be said that these researchers have contributed to enhancing the level of science and technology in foreign countries where they have been working. Concerning the larger number of Japanese researchers going to Western countries, some concerned observers pointed to the closed nature of Japan in the international exchange of researchers. But the essential problem that Japan must seriously consider in this connection concerns whether the present level of science and technology and research environment in this country are attractive enough to the researchers of Western countries to encourage them to come to Japan for study and research. It is important for Japan to raise standards in these areas. Considering the fact that in recent years Japan has fast been catching up technologically with most advanced countries, it is now becoming more important to take positive action to receive more foreign researchers. In this regard, it is necessary for Japan to provide prospective foreign researchers with more detailed information about the research institutions here and upgrade the lodging facilities, in addition to improving research environments.

As for research facilities, with increasing sophistication and complexity of R&D endeavors in recent years, the need for more sophisticated and larger-scale equipment and facilities is increasing. It is desirable that these facilities be made more available to foreign researchers. From now on, more consideration must be given to this in building and operating new research facilities.

Holding an international conference in Japan gives Japanese researchers a chance to contact their foreign counterparts, and foreign researchers a chance to visit Japan and directly observe the science and technology of Japan. Considering this, holding such a conference would contribute significantly to the internationalization of this country's science and technology. Though Japan is geographically far from the United States and Europe, it is important to make efforts to have more international conferences held here, by enhancing the level of science and technology and improving various services needed to hold such a conference.

Much of the criticism from foreign countries about the closed nature of the R&D system in Japan can be traced to the problems of language and inadequate living environments, problems which this country must overcome in its present internationalization efforts.

3. Contribution to the World in Science and Technology

Today, Japan has grown to the No 2 economic power in the free world, and in the field of science and technology it has almost caught up with the front-running group. For this, the country is required to make stepped-up efforts to play its role for the development of the world in the fields of industry-related technology, the field where Japan has made remarkable achievements, and basic research by producing useful results that can be shared with other countries. Along with these efforts Japan is also required to promote technology transfer and to help tackle global-scale problems and problems common to mankind through its scientific and technological contribution to the world. In Japan, having joined the group of scientifically and technologically most advanced nations, the private companies are required to follow the national efforts in promoting harmonious development of science and technology, by recognizing the increased influence that Japan enjoys in international society today.

Today, many developing countries want a system of international division of labor to be established, by promoting technology transfer from technologically advanced nations to them along with direct investments they are receiving. They want the establishment of the system to lead to the prosperity of their economy and society. As described in Chapter 3, Japan has been extending cooperation to developing nations in various forms--receiving trainees, dispatching experts and transferring technology. The technology transfer has been implemented in connection with Japanese companies' start of local operations in these countries. Japan is required to continue this cooperation on a long-term basis and step up cooperation to contribute to the development of science and technology in developing countries. With the drastic appreciation of the yen against the U.S. dollar in recent years, an increasing number of export-oriented Japanese companies are moving part of their operations to foreign countries. By taking advantage of this, it is necessary for these companies to contribute to enhancing the technological standards of these countries by promoting the transfer of Japan's advanced production technology, in addition to increasing employment in the countries. At the same time, it is also important for Japan to make increased efforts to open its research facilities to able researchers in developing nations. To ensure harmonious development of science and technology in Japan, it is important to contribute to the prosperity of the world economy and society, by promoting technology transfer and cooperation in R&D fields.

4. Conclusion

As described so far in this white paper, Japan must continue efforts to further enhance the country's science and technology standards to the point where foreign researchers want to come to Japan for research. To encourage them to come to this country, the research environments must be improved

further as soon as possible. Beefing up the basic research system is one way. It is important for Japan to proceed with the effort, aiming at achieving harmonious development of science and technology commensurate with its national power.

Considering Japan's international position and the responsibility that it now must assume in international society, this country must step up research cooperation and the exchange of information and researchers, and establish a science and technology promotion system meeting the requirements of the internationalization effort.

With Japan now becoming a member of the group of technologically most advanced nations, the internationalization effort must not be confined to efforts to catch up with the United States and Europe. What is needed is to proceed with the internationalization effort flexibly by taking into account the differences between Japan and foreign countries.

The problems of language and the geographically disadvantageous location of Japan require that it make more efforts than Western nations do in the internationalization effort. By overcoming these problems, Japan will contribute to the world through the promotion of internationalization and further enhancing its science and technology standards commensurate with its international position, by recognizing its responsibility as a technologically most advanced nation. In fact, foreign countries' expectations of Japan are mounting. To meet these expectations, Japan has been introducing various measures and is now required to strengthen these measures to meet the mounting expectations. Under these circumstances, the importance of the role that the government must play to push the internationalization of this country's science and technology is increasing. At the same time, not only the government but also the private companies, academic/research societies and individual researchers are all required to make their respective efforts now to deal with the problems discussed in this white paper.

One more important thing is for Japan to try to use every opportunity possible so foreign countries will have correct perceptions of Japan's efforts for internationalizing its science and technology.

The efforts that Japan must make to internationalize the country's science and technology have already been made by the technologically developed United States and European countries in the past. For Japan to play its international role properly as a technologically developed nation, the country must seriously tackle the three major tasks that were pointed out and discussed in this chapter and produce results. Through these efforts, Japan could promote the internationalization of science and technology.

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Trends in Research Activities

43063506c Tokyo KAGAKU GIJUTSU HAKUSHO in Japanese 10 Feb 88 pp 103-144

[Text] **Section 2. Chapter 1. Trends in Research Activity**

Whenever Japanese society tries to cope with such subjects as the problems associated with resources, energy, environment, and safety, the transition toward an aging society, deep involvement in serious trade friction, achieving steady economic growth under international cooperation, or to make improvements in the quality of life, science and technology plays an increasingly more important role than previously. In responding to this circumstance, the further strengthening of research activity, particularly in the areas of research investment and manpower, is strongly recognized as being the means for solving various subjects requested for science and technology.

An outline of all research activities[1] in Japan will be discussed in this chapter. At the same time, the trend of research expenses and manpower and its comparison with that of foreign countries will also be mentioned. In the beginning, research activity in general will be discussed, and then each organization,[2] including "companies," "research institutes," and "universities," will be examined.

1. Limited to the research activity of natural science, excluding cultural and social sciences. The difference between natural science and cultural and social sciences is made by the research operation organization division (a department is used as a division in the case of a university).

2. "Companies" refer to corporations (capital of more than ¥1 million before 1974, more than ¥3 million between 1975 and 1978, and more than ¥5 million after 1979), and special corporations which mainly conduct business. For example, Japan Railroad Co., the Japanese Broadcasting Corp., and Japan Highway Public Corp. are distinguished as special corporations.

"Research institutes" refer to government-managed, municipal and private research organizations, and special corporations which deal mainly with research and development. The National Space Development Agency, Power Reactor and Nuclear Fuel Development Corp., Japan Atomic Energy Research Institute, and Institute of Physical and Chemical Research are recognized as these special corporations.

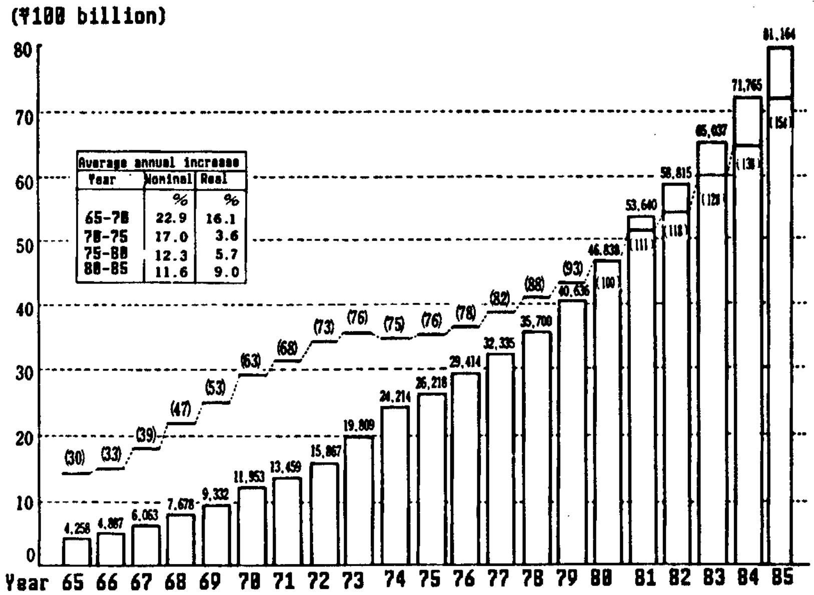
"Universities" include departments of a university, including a graduate school, junior college, laboratories affiliated with universities, institutes jointly operated by national universities, and matriculation centers.

1. Outline of Research Activity

(1) Research Expenses[3]

(Total research expenses)

The total research expense is one of the main indices indicating the trend of research activity. Total research expenditures for FY 1985 in Japan was ¥8.1164 trillion.[4] This was an increase of 13.1 percent over the ¥7.1765 trillion of the previous year. When substantial research expenses, calculated by a research expense deflator were examined for the past few years, it had remained on the same level for 1974 and 1975, but basically increased beginning in 1976. It was still increasing in 1985 (Figure 2.1.1).



Note 1: Figures in ( ) are based on an index of real research expenses (1980 = 100)
2: A deflator is based on attached material 32.

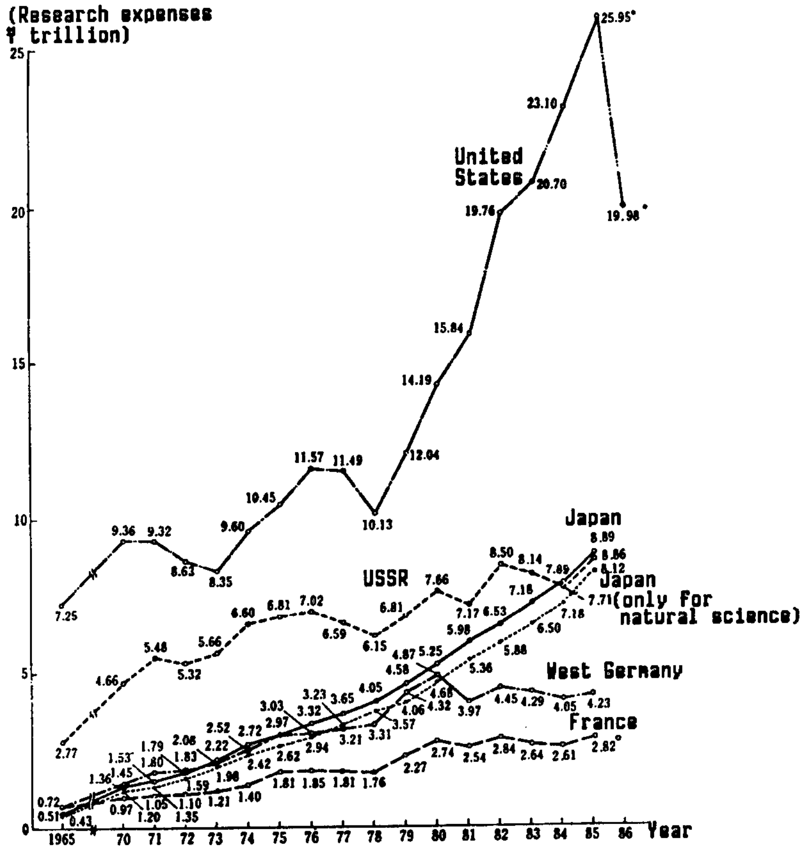
Source: Generated from "Science and Technology Research Survey Report" by Statistics Bureau, General Affairs Agency

Figure 2.1.1. Research Expenses in Japan

3. Research expenses means expenses spent for research by companies, research institutes, and universities. There are two figures--one is the expenditure, while the other is the amount of expenses. The former is used in this report. It includes personnel expenses, the cost of raw materials, purchasing expenses for tangible fixed assets, and other expenses required by the research. The latter indicates the amount being appropriated by tangible fixed assets depreciation instead of purchasing expenses for tangible fixed assets.

4. It means research expenses needed in the area of natural science. For reference, research expenses spent on cultural and social sciences was ¥773.9 billion in 1985. This is about 9.5 percent of the amount spent on natural science.

A quantitative comparison of research expenses among different countries is difficult to make due to differences in contents and the investigative method. However, research expenses announced by major countries were compared in order to see the general trend of research activity in these countries. The results indicate that the United States is head and shoulders above the rest in research expenses. The Soviet Union is in second place, followed by Japan and West Germany in third place. A large increase in research expenses was observed in these two countries from the latter half of the 1960s to the first half of the 1970s (Figure 2.1.2).



Note 1: In order to make a comparison among countries, cultural and social sciences are included. Regarding Japan, research expenses for natural science alone are also indicated.

2. * indicates estimated values, and o indicates temporary values.

3. Conversion into Japanese yen is based on attached material 33.

Source: Japan--"Science and Technology Research Survey Report" by Statistics Bureau, General Affairs Agency

United States--NSF (National Science Foundation), "National Patterns of Science and Technology Resources"

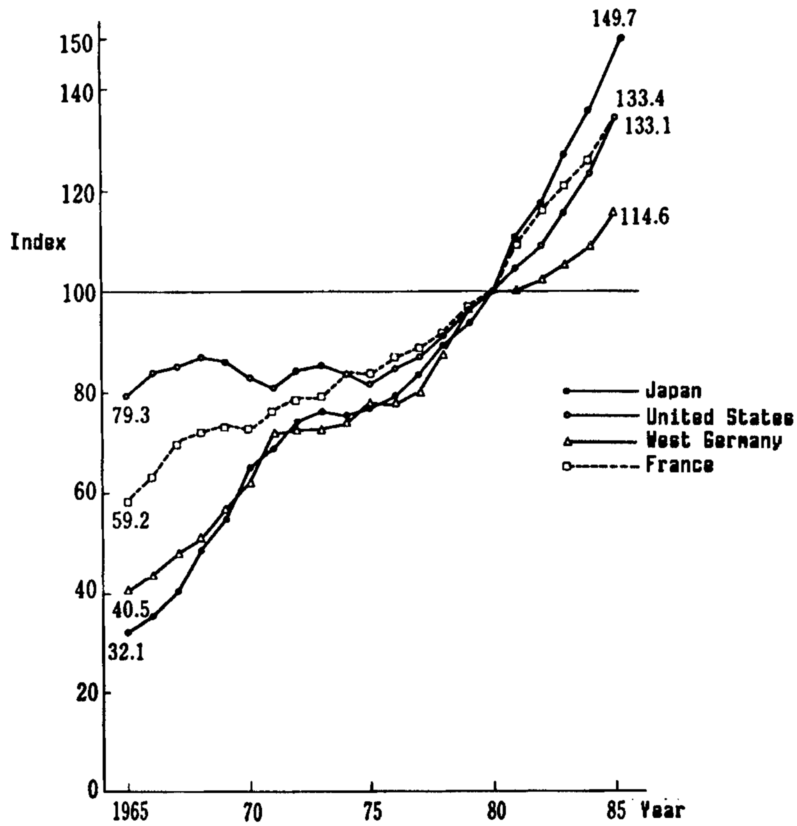
West Germany--"Faktenbericht zum Bundesbericht Forshung 1986"

France--"Budget Bill Supplementary Documents"

USSR-- "The Soviet Union People Economics Statistical Almanac," Central Statistics Bureau, Soviet Cabinet Meeting

Figure 2.1.2. Change in Research Expenses in Major Industrial Nations

Real research expenses were calculated based upon the 1980 standards for Japan, the United States, West Germany, and France. Then, their increases were compared. A rapid increase is seen in Japan and West Germany, while after 1981, instead of West Germany, France shows a rapid increase. Nevertheless, Japan maintains the highest increase rate in research expenses (Figure 2.1.3).



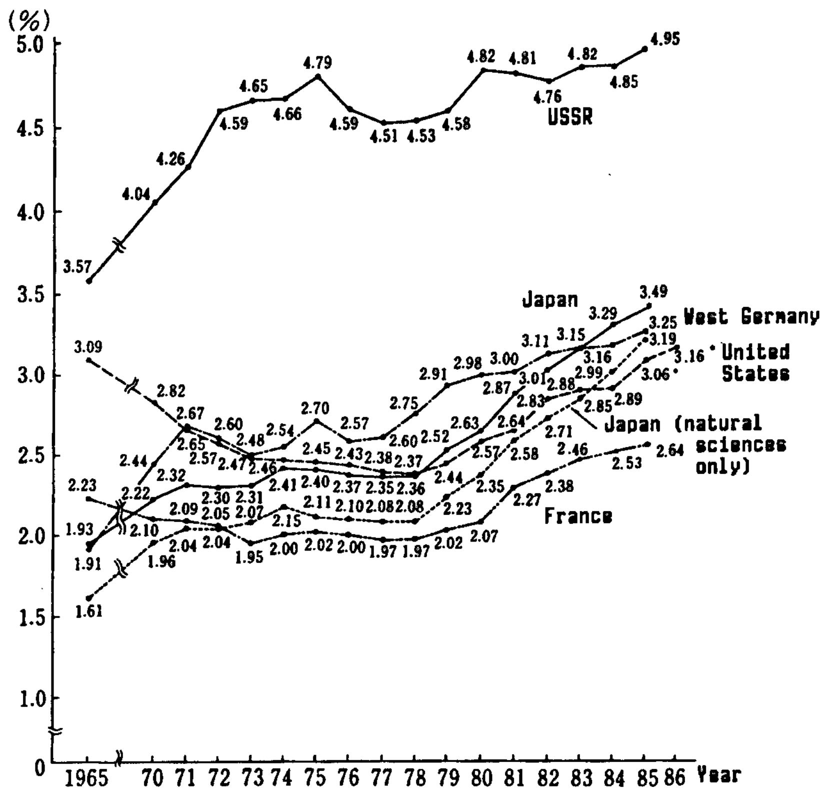
Note 1: In order to make an international comparison, cultural and social sciences are included.
2: A deflator is referred to from attached material 32.
3: A comparison is made using 1980 as an index of 100.

Source: Generated from the data shown in Figure 2.1.2.

Figure 2.1.3. Real Growth of Research Expenses in Major Industrial Nations

The ratio of research expenses to national income was viewed as an indicator of the level of nationwide research investment. The results indicate that it decreased slightly, or remained stable, from 1971 through 1979 from the worldwide viewpoint. After 1979, however, it started to increase, and continues to increase steadily. Among these countries, Japan's growth rate is remarkable. In 1985, the ratio was 3.49 percent when including cultural and social sciences, while it was 3.19 percent for natural science alone. These values are the highest yet achieved.

The Science and Technology Council emphasizes that the ratio of research expenses to national income in the area of natural science will be 3 percent for a while, not the long-term 3.5 percent reported in the inquiry No 11 "Synthetic Fundamental Policy of Science and Technology Promotion Under a Long-Term View Corresponding to a New Change in the Situation." The immediate objective has been achieved, and people's attention at this stage seems to be placed on when the next objective will be accomplished (Figure 2.1.4).



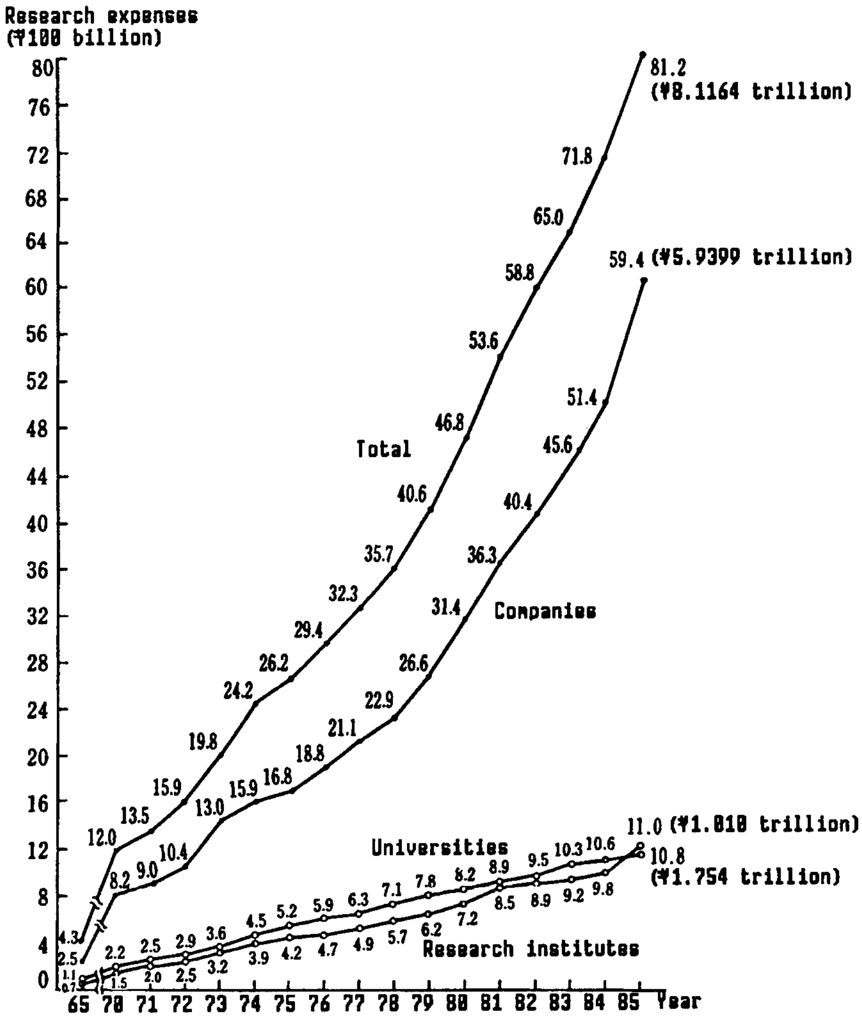
Note: The same as those of Figure 2.1.2.
Source: The same as those of Figure 2.1.3, except that national income is drawn from attached material 1.

Figure 2.1.4. Change in Ratio of Research Expenses to Gross National Income in Major Industrial Nations

This is believed to have been fueled by the fact that the importance and necessity of science and technology has become recognized, and research and development have been conducted intensively nationwide due to Japan's rigorous environment, both internally and externally. Particularly, the positive strengthening of research and development investment at private enterprises and organizations, the government's securing of a budget for science and technology activity, and the positive results of long-term steady efforts toward private science and technology promotion are apparent.

(Research expenses spent by organizations)

When the research expenses spent by each organization are examined, companies share a large portion of the ratio. In 1985, companies spent ¥5.939.9 trillion (an increase of 15.6 percent over the previous year) for research expenses, which was 73.2 percent of the total. Universities spent ¥1.0754 trillion (13.2 percent; an increase of 1.1 percent), and research institutes spent ¥1.101 trillion (13.6 percent; an increase of 12.8 percent) (Figure 2.1.5).

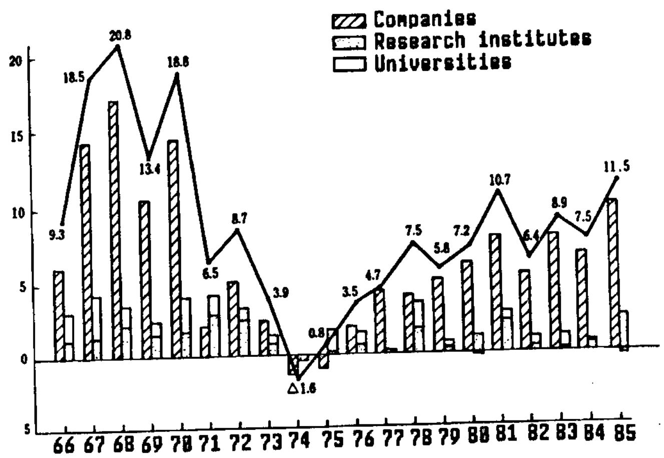


Source: "Science and Technology Research Survey Report" by Statistics Bureau, General Affairs Agency

Figure 2.1.5. Research Expenses in Japan by Kind of Organization

When the relationship between an increase in total research expenses and research expenses classified by a type of organization is observed, it is seen that the movement of research expenses in Japan is influenced by the amount spent on research by companies. Japan was experiencing a high growth rate in the second half of the 1960s. At that time, the companies'

research expenses increased and, as a result, the total amount of research expenses increased rapidly. However, starting early in the 1970s, the increase in total research expense dimmed. Along with the influence of the post-oil crisis, the annual increase in companies' research expense rates turned negative from 1974 through 1975. Accordingly, the annual increase rate in the total research expenses also decreased. After 1976, companies' research expenses gradually started to increase again. By taking that phenomenon as the turning point, Japan's total research expenses started to grow again (Figure 2.1.6).



Note: A deflator is referred to from attached material 32.

Source: Generated from "Science and Technology Research Survey Report" by Statistics Bureau, General Affairs Agency

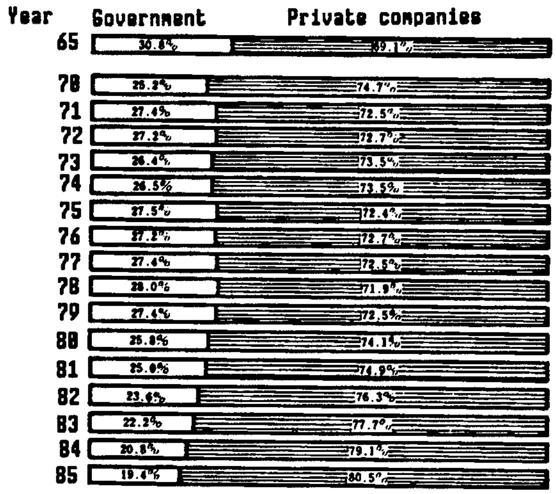
Figure 2.1.6. Change in Rate of Relative Contribution to Real Annual Growth of Research Expenses in Japan by Kind of Organization

(Proportion of research expenses by source of funds)

When the proportion of research expenses funded by the government* and private organizations is examined, 19.4 percent (¥1.574 trillion) is for the government, 80.5 percent (¥6.5346 trillion) for private organizations, and 0.1 percent (¥7.8 billion) for foreign countries in 1985 (Figure 2.1.7).

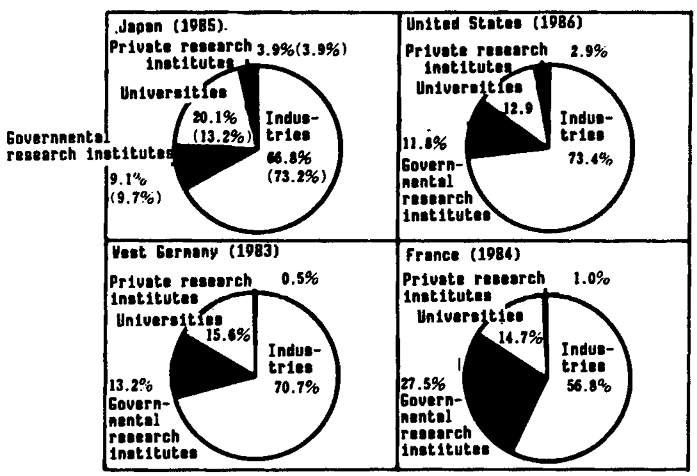
The proportion of research expenses by participant in the major industrial nations (Japan, the United States, West Germany, France) indicates that the industrial field occupies about two-thirds. This ratio is almost the same among these countries (Figure 2.1.8).

*: Refers to national and local public organizations mentioned in "Science and Technology Research Survey Report" by the Statistics Bureau, General Affairs Agency, in this chapter.



Note 1: Government refers to national and local public organizations.
2. About 0.1 percent of total research expenses is funded annually by foreign countries.
Source: "Science and Technology Research Survey Report" by Statistics Bureau, General Affairs Agency

Figure 2.1.7. Proportion of Research Expenses by Source of Funds



Note 1: Cultural and social sciences are included for international comparison.
2: The figures used for the United States are estimates.
Source: Japan--"Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency
United States--NSF, "National Patterns of S&T Resources"
West Germany, France--OECD Statistics

Figure 2.1.8. Proportion of Research Expenses by Participant in Major Industrial Nations

The flow of research expenses among industries, universities, and government has been compared for these countries. The results show that there was less flow in Japan than in other countries (Table 2.1.9). The reason for less flow from the government to universities in Japan is that

Table 2.1.9. Money Flow Relationship in Total Research Expenses of Government, Industry, and Universities

Source of contribution	Organization using Funds	Japan 1986		United States 1985		West Germany 1985		France 1983	
		Research expenses	Share %	Research expenses	Share %	Research expenses	Share %	Research expenses	Share %
		¥100 million	%	¥100 million	%	¥100 million	%	¥100 million	%
Government	Industries	978	1.6	62,010	32.7	5,194	17.4	3,361	22.4
	Government	7,665	94.5	31,363	100.0	1,446	94.9	6,663	95.6
	Universities	9,379	54.4	22,538	73.3	5,517	94.5	4,078	97.6
Industries	Industries	58,231	98.0	127,598	67.3	24,074	80.9	10,940	73.0
	Government	434	5.4	0	0	28	1.9	48	0.7
	Universities	277	1.6	1,312	4.3	324	5.5	54	1.3

Note: Share means the ratio of funds, by contributor, to the total research expenses of all organizations.

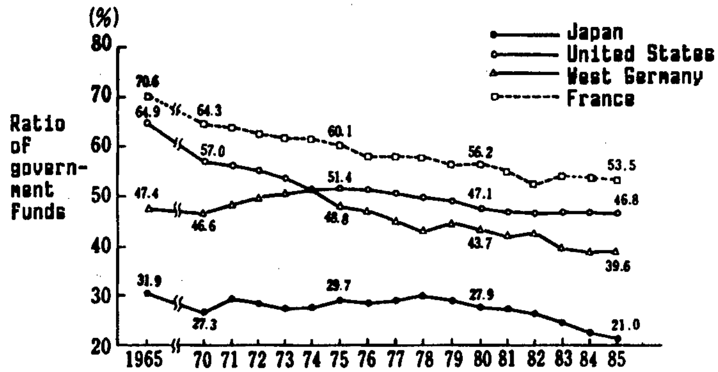
Source: Japan--"Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency
United States--NSF, "National Patterns of Science and Technology Resources"
West Germany--BMFT "Faktenberichet 1986 zum Bundesbericht Forshung"
France--Generated from OECD statistics

each body (government, university, or enterprise) is considered as an entity. This means that there has been almost no contact among the bodies in the past. Furthermore, it should be pointed out that private vitality is much more trusted in research and development in Japan than it is in other countries. There is a lot of flow among the organizations in the United States which have national defense research expenses.

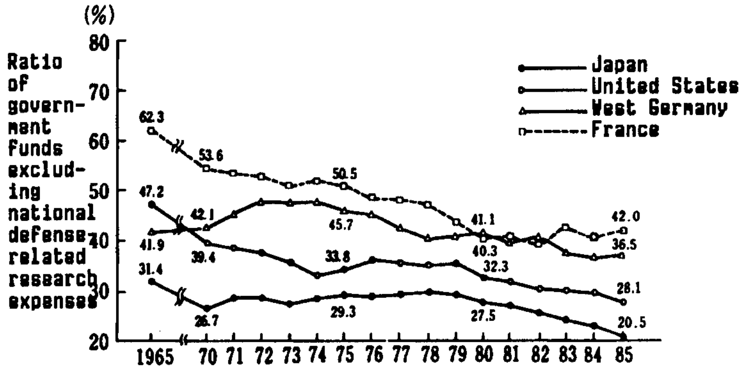
With respect to the ratio of government funds, the weight of national defense research expenses is low in Japan. It is difficult to make a simple comparison among countries since there is a difference in the incidence rate of a tax and private vital energies. Nevertheless, when a comparison is made, a ratio of government funds, including cultural and social sciences, is 21 percent, while it is 19.4 percent for natural sciences only in Japan in 1985, 53.5 percent in France (1985), 46.8 percent in the United States (1985), and 39.6 percent in West Germany (1985) (Figure 2.1.10). These ratios tend to decrease gradually from the long-range viewpoint. This trend is due mainly to positive activity in research and development investments in industrial fields.

The ratio of government funds, excluding national defense-related R&D expenditures, in Japan is 20.5 percent when cultural and social sciences are included, and is 18.8 percent for natural sciences alone. On the other hand, it is 42 percent in France, 36.5 percent in West Germany, and 28.1 percent in the United States. There is quite a difference in the ratio between Japan and major countries in Europe and America (Figure 2.1.10).

(1) Ratio of government funds



(2) Ratio of government funds excluding national defense-related research expenses



Note: 1. The ratio of government funds excluding national defense-related research expenses (%) is calculated by

$$\frac{\text{government funds - defense related research expenses}}{\text{research expenses - defense related research expenses}} \times 100$$

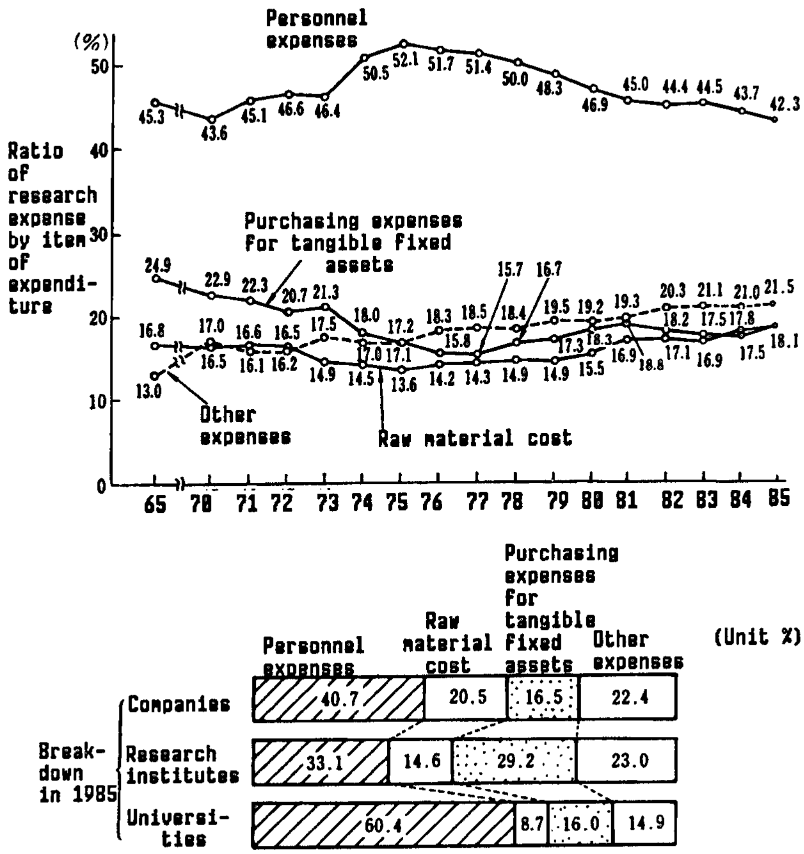
2. The ratios for the United States in 1985 and 1986 are estimates.
3. The ratio of government funds, excluding national defense research expenses, for West Germany in 1985 is the the provisional value.
4. In order for an international comparison to be possible, cultural and social sciences are included.

Source: The same as for Figure 2.1.3.

Figure 2.1.10. Change in Ratio of Government Financed Research Expenses

(Research expenses categorized by item of expenditure)

Research expenses consist of personnel expenses, raw material costs, purchasing expenditures for tangible fixed assets (land, building, machinery, apparatus, equipment, etc.), and other expenses. When a change in the ratio of research expenses, categorized by each item of expenditure, is examined, the proportion of personnel expenses is the largest. It showed a tendency to increase in the first half of the 1970s, and then it decreased in the second half of the 1970s. It was 42.3 percent in 1985.



Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.11. Change in Proportion of Research Expenses by Category of Expenditure

There is a tendency for the ratio of the raw material cost to increase slightly for several years. It was 18.1 percent in 1985. The ratio of purchasing expenses for tangible fixed assets was also 18.1 percent in 1985.

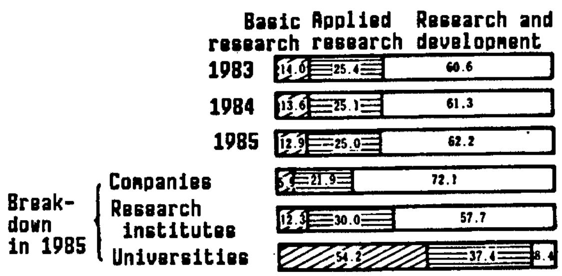
As for other expenses, such as the book budget, office expenses, traveling expenses, and communication expenses, which are required for research activity, the tendency exists for them to increase slightly. It was 21.5 percent in 1985 (Figure 2.1.11).

When the ratio of research expenses is categorized by organizations, the raw material cost ratio is larger than the others in a company, while the purchasing expenses for tangible fixed assets ratio is large in a research institute. In the case of a university, the personnel expenses ratio is high (Figure 2.1.11).

(Proportion of research expenses by character of work)

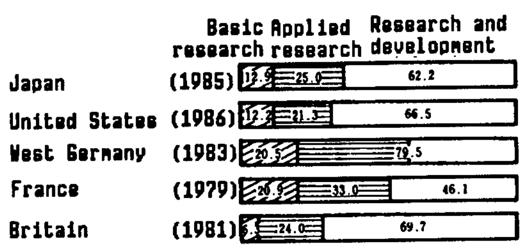
The observation of a change in the proportion of research expenses according to the character of work, such as basic research, applied research, and research and development, indicated that the ratios of basic and applied research decreased slightly, while that of research and development increased in 1985.

When the proportion of research expenses by character of work is classified according to the organization, the characteristics of each organization, i.e., a university, a research institute, and a university, are observed. Namely, the ratio of research and development becomes large in the case of a company because it is necessary for the enterprise's activity. On the contrary, basic and applied research are given much weight in a university. A research institute is thought of as somewhere in the middle of these two organizations (Figure 2.1.12).



Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.12. Proportion of Research Expenses in Japan by Character of Expenditure



Note: 1. Only natural science is included in Japan, West Germany, and Britain. Both cultural and social sciences are included in the United States and France.
2. Applied research and research and development are not separated in West Germany.
3. Private research institutes are not included in West Germany.
4. Universities are not included in Britain.

Source: The same as Figure 2.1.8. OECD statistics used for Britain.

Figure 2.1.13. Proportion of Research Expenses in Major Industrial Nations

The proportion of research expenses according to the character of work in the major industrial countries shows that the ratio of research and development is relatively large in the United States, while that of basic research is large in West Germany and France. Japan lies between these countries (Figure 2.1.13).

(Research expenses with specified objective)

Next, research expenses spent for five specified objectives--nuclear energy development, space development, ocean development, information processing, and environmental protection*--were investigated. The total amount of research expenses spent for these objectives was ¥1.1405 trillion in 1985. It showed an increase of 13.6 percent over the previous year. This amounted to 14.1 percent of the total research expenses (14 percent in 1984). These objectives hold an important position in the area of research and development. When they are classified according to the amount of their research expenses, information processing stands first (an increase of 15.8 percent over the previous year), followed by nuclear energy development (an increase of 9.9 percent), space development (an increase of 25.3 percent), environmental protection (an increase of 7.5 percent), and ocean development (an increase of 8.1 percent) (Figure 2.1.14).

Regarding energy research expenses, including nuclear energy, starting in 1976, the total amount of energy research expenses was ¥758.3 billion. The ratio of fossil energy research for petroleum, natural gas, and coal was 11 percent, that of natural energy research for geothermal energy and solar energy was 4.9 percent, that of nuclear energy research was 46 percent, that of energy saving research was 35 percent, and that of other energy research was 3.1 percent. When these energy research expenses are categorized by type of organization, it is seen that companies spend them mostly on fossil energy, natural energy, and energy saving, while research institutes are interested in nuclear energy. The detailed observation of each energy research field indicates that research expenses for petroleum are prominent in the area of fossil energy, expenses for solar energy are mainly used for natural energy, those for atomic power generation are spent for nuclear energy, and those for industrial and transportation areas are the main interests for energy saving (Figure 2.1.15).

Research expenses used for life sciences amounted to ¥877.5 billion in 1985. Seventy percent of the research expenses was for the expenditure related to health and medical treatment (Figure 2.1.16). Research expenditures, especially for gene recombination reached ¥36.2 billion, which was 4.1 percent of the life science research expenses.

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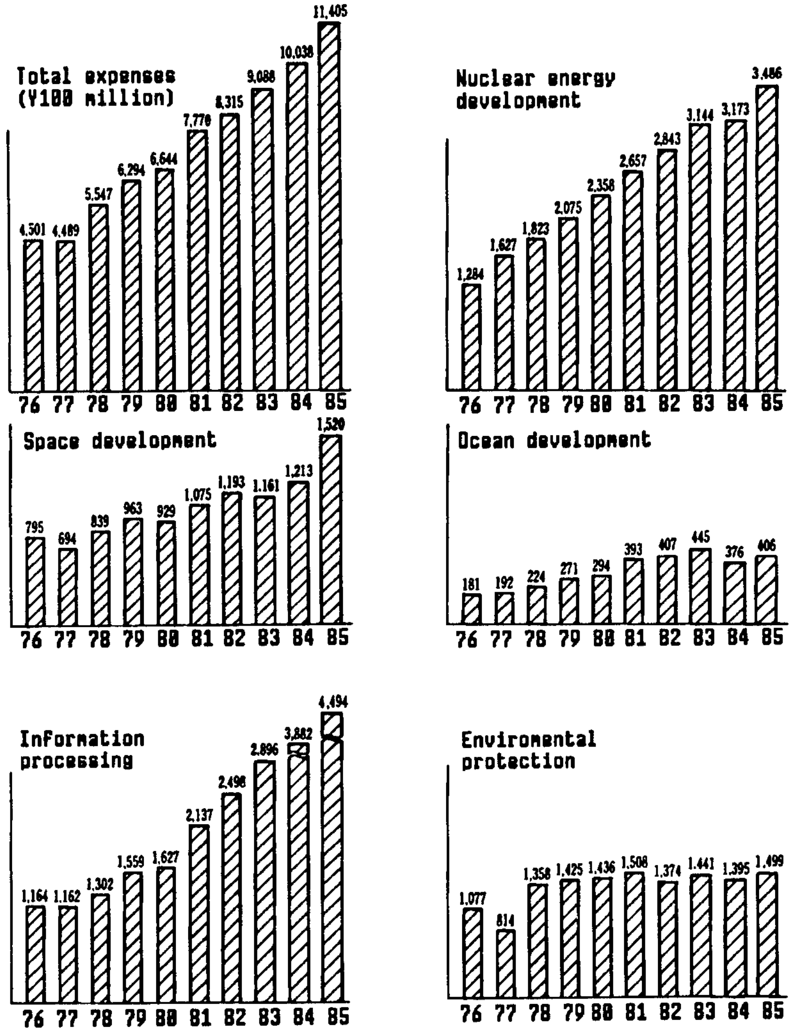
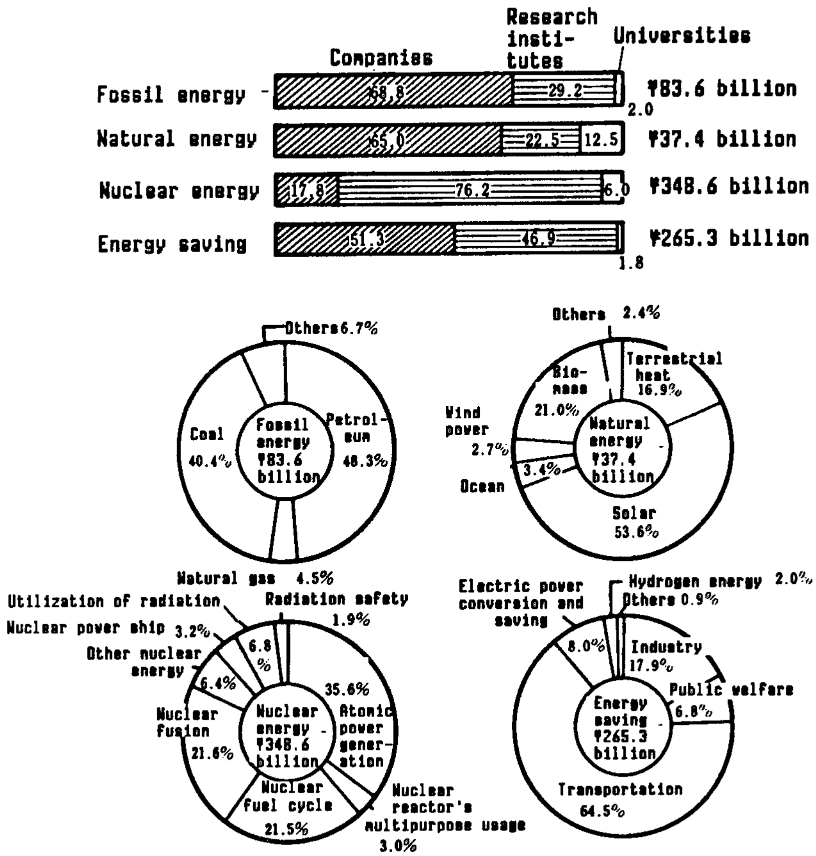
*: This term is used in the "Science and Technology Research Survey Report," by Statistics Bureau, General Affairs Agency, and refers to research related to the "prevention of environmental pollution."



Note: Only companies capitalized at more than ¥100 million are included.

Source: "Science and Technology Research Survey Report," General Affairs Agency.

Figure 2.1.14. Change in Research Expenses by Specific Objective



Note: Only companies capitalized at more than ¥100 million are included.

Source: "Energy Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.15. Energy-Related Research Expenses (1985)

(Research expenses per researcher)

Research expenses per researcher was ¥21.29 million in 1985. This was an increase of 9.8 percent over the previous year.

Although real research expenses per researcher decreased due to the increased cost of living following the oil crisis, it increased gradually beginning in the second half of the 1970s. In 1985, it was ¥18.87 million, which was an increase of 8.2 percent over the previous year (Figure 2.1.17).

A research institute spends the largest amount of research expenses per researcher annually. If for instance, a research institute spent ¥34.23 million in 1985, a company would have spent ¥25.7 million, and a university ¥9.11 million. The research institute and company showed increases in expenses per researcher, i.e., 12.2 percent and 12 percent, respectively, compared to those of the previous year. However, in the case of the university, there was a decrease of 2.3 percent (Figure 2.1.17).

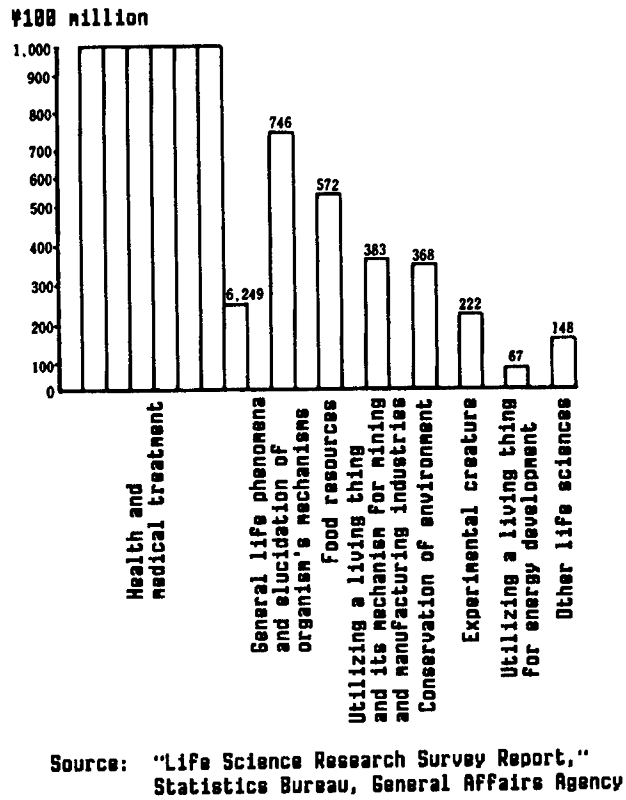
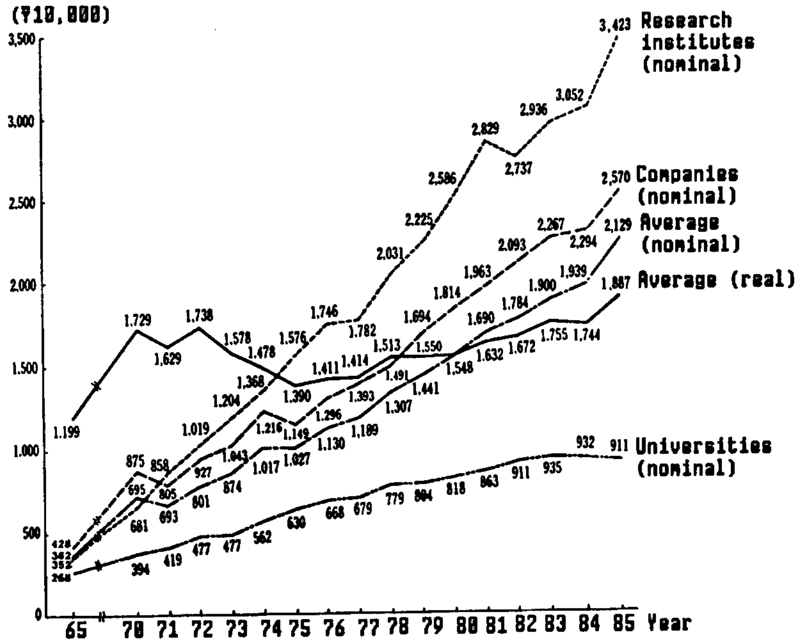


Figure 2.1.16. Life Science Research Expenses by Objective (1985)

It is difficult to make a simple comparison due to the differences existing in research systems among the major industrial countries. Nevertheless, the figures are as follows: Japan spent ¥19.86 million per researcher in 1985 (¥21.29 million for natural sciences alone), West Germany spent ¥32.25 million in 1983, the United States ¥32.85 million in 1985, and France ¥26.62 million in 1984 (Figure 2.1.18).

Personnel expenses constitute the largest share of research expenses per researcher in West Germany and France, with its ratio being 59 percent in West Germany in 1983, and 60 percent in France in 1977, while it was 45 percent (42 percent for natural sciences only) in Japan in 1985. This is mainly due to the fact that there are a large number of research assistants per researcher in West Germany and France, which actually influences personnel expenses. When expenses per researcher, not including personnel expenses, is examined, it is seen that Japan expended ¥11 million in 1985 (¥12.2 million only for natural sciences only), while West Germany and France spent ¥12.27 million (1983) and 10.8 million (1977), respectively.



Note: Research expenses per researcher are calculated such that expenses of the specific budget year are divided by the number of researchers registered at the beginning of the year (1 April). The average figure (real) is based upon the numbers obtained in 1980.

Source: Generated from "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.17. Change in Research Expenses Per Researcher

(2) Manpower for Research Activity

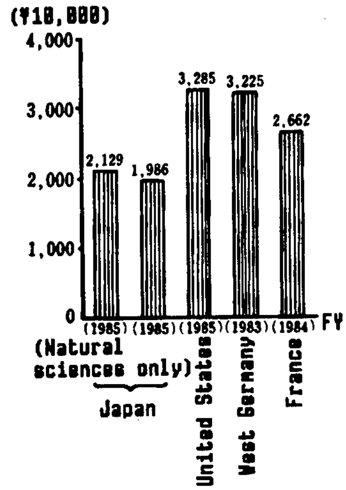
People engaged in research and its related activities can be classified into researchers, research assistants, technicians, office workers, and others. The classification of people participating in research and its related activities is as follows:

Researcher: Graduate of a university (junior college not included) with more than 2 years experience in research, and also conducting research toward a specific objective (or person who has equivalent expertise). A researcher who has an additional job is not included in the number of researchers quoted in this report (however, research expenses includes the expenditure required for such a researcher).

Research assistant: Person who assists a researcher, and is engaged in research under the researcher's guidance. He/she might become a researcher in the future.

Technician: Person other than a researcher or a research assistant who is engaged in technical service related to research under the guidance and supervision of a researcher and a research assistant.

Office worker and others: Person other than a researcher, a research assistant, or a technician, who is mainly engaged in miscellaneous businesses, general affairs, accounts, etc.



Note: 1. In order for an international comparison to be made, cultural and social sciences are included. For Japan, the figure for natural sciences only is also shown.
2. The figure for the United States is an estimate.
3. Conversion to Japanese yen is based on attached material 33.

Source: The same as for Figure 2.1.3. However, the number of West German researchers is taken from OECD statistics.

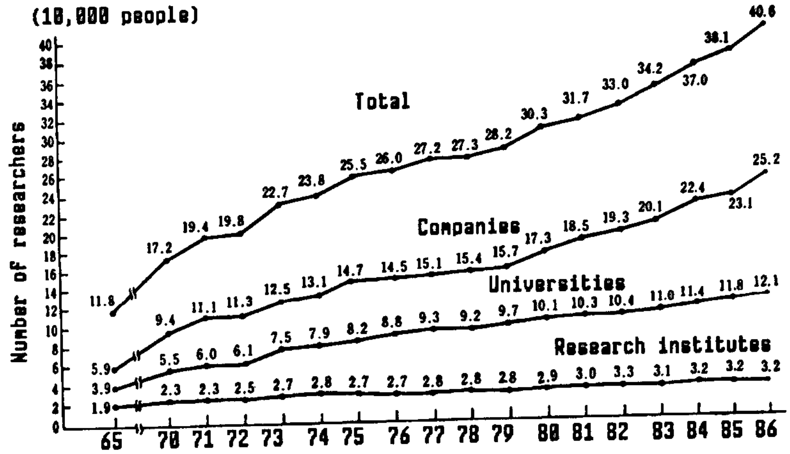
Figure 2.1.18. Comparison of Research Expenses Per Researcher in Major Industrial Nations

(The number of researchers)

The total number of researchers involved in research activity in Japan as of 1 April amounted to 406,000. This was an increase of 6.4 percent over the previous year's total of 381,000 (Figure 2.1.19).

The average annual rate of increase after 1965 was 7.9 percent during 1965-1970, 8.2 percent during 1970-1975, 3.5 percent during 1975-1980, and 5 percent during 1980-1986. Although the increase rate seemed to peak during the second half of the 1970s, it remained relatively high in the 1980s.

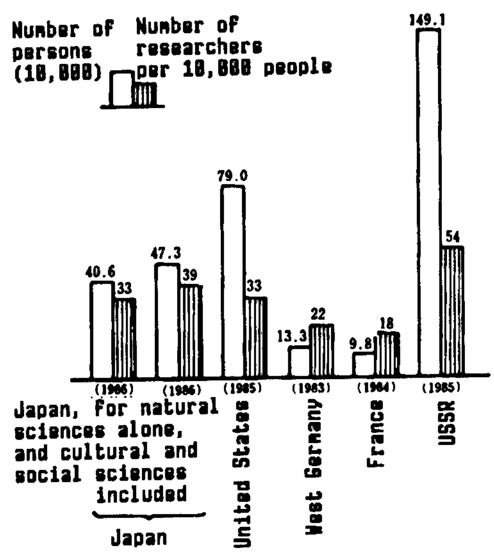
The number of researchers, as classified by organization, amounts to 252,000 in companies, comprising 62.1 percent of the total number of researchers (an increase of 8.9 percent over the previous year). This is followed by 121,000 in universities, or 29.9 percent (an increase of 2.8 operation), then 32,000 in research institutes, or 8 percent (an increase of 0.9 percent) (Figure 2.1.19).



Note: The number of researchers is as of 1 April for every year.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.19. Change in Number of Researchers



Note: 1. In order for an international comparison to be made, cultural and social sciences are included. For Japan, the figures for natural sciences only are also shown.
2. The number of researchers per 10,000 people used for the United States comes from 1984 data.
3. The figures used for the United States are estimates.

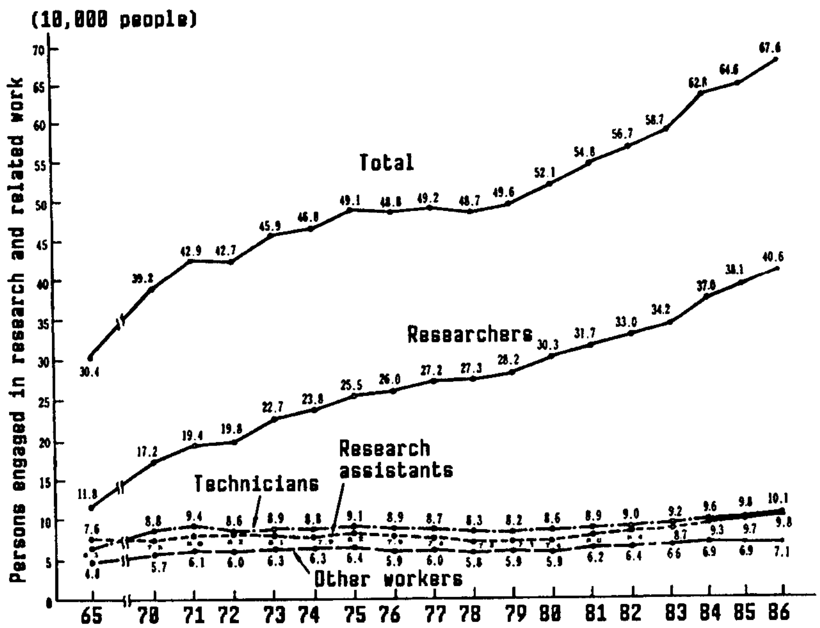
Source: The same as for Figure 2.1.3. The figures for West Germany are obtained from OECD statistics. Population is obtained from UN statistics.

Figure 2.1.20. Comparison of Number of Researchers Among Major Industrial Nations

Although it is difficult to compare simply the number of researchers among countries due to the differences in the methods of conducting surveys and their objectives, the number of researchers obtained by statistical study conducted by each major industrial country is compared as an index for the country's general trend. The results show that the Soviet Union has 1.464 million researchers (1984), which is the highest figure. This is followed by the United States, with 790,000 researchers (1985). These numbers are, respectively, 3.6 and 1.9 times larger than the number of researchers in Japan. However, the numbers for West Germany and France are lower than those of Japan. Regarding the number of researchers per 10,000 people, Japan is on the same level as the United States (Figure 2.1.20).

(The number of persons engaged in research and its related work)

The number of persons engaged in research and its related work was 676,000 in 1986. This was an increase of 4.6 percent over the 646,000 of the previous year (Figure 2.1.21). The ratio of researchers to the number of persons engaged in research and its related activities increased from 59 percent in the previous year to 60 percent. On the other hand the number of research assistants, technicians, and other workers decreased from 15 percent to 14.6 percent, from 15.2 percent to 14.9 percent, and from 10.8 percent to 10.5 percent, respectively.

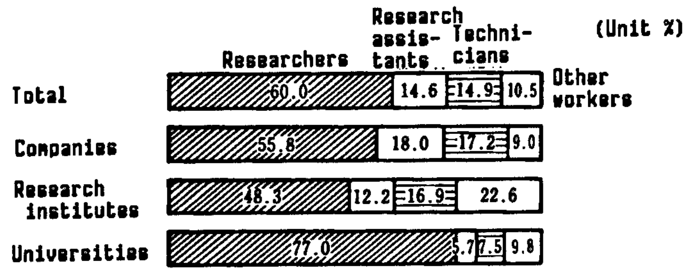


Note: Figures as of 1 April annually.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.21. Change in Number of Persons Engaged in Research Related Work

The proportion of people engaged in research and its related activities by kind of organization shows that the ratio of research assistants and technicians is larger in companies than in other organizations. For universities, the ratio of researchers is very high, actually reaching 77 percent (Figure 2.1.22).



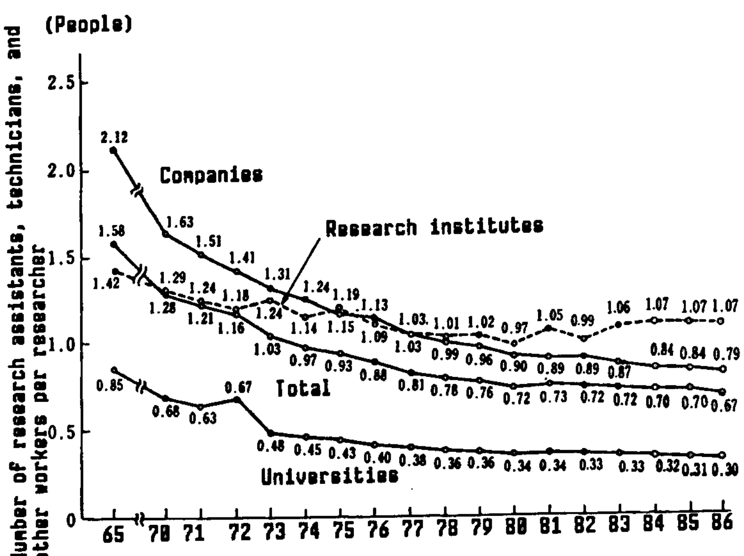
Note: Figures as of 1 April every year.

Source: "Science and Technology Research Survey Report," Statistical Bureau, General Affairs Agency

Figure 2.1.22. Proportion of Persons Engaged in Research Work by Kind of Organization (1986)

(The number of research assistants per researcher)

There is the tendency for the numbers of research assistants, technicians, and other workers to decrease. It was 0.67 people in 1986 (Figure 2.1.23).



Note: 1. The total number of research assistants, technicians, and other workers per researcher.
2. Figures as of 1 April every year.

Source: Generated from "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.23. Change in Number of Research Assistants Per Researcher

2. Research Activities of Organizations

(1) Research Activities of Companies

(i) Research activities of companies

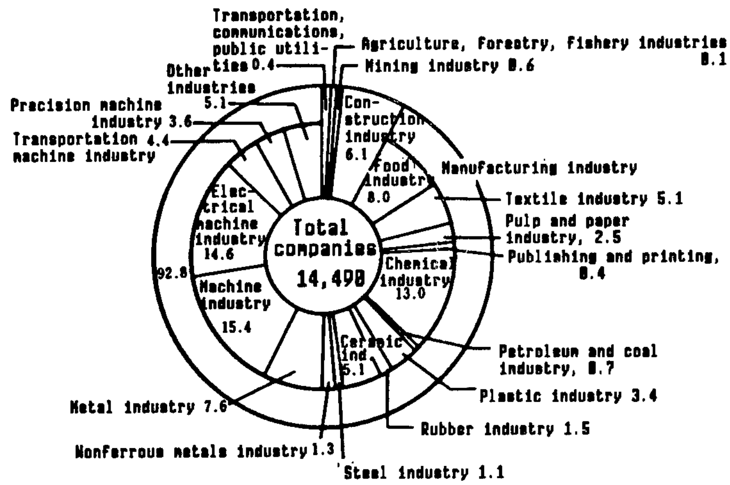
Research expenses spent by companies in 1985 amounted to ¥5.9399 trillion, which was an increase of 15.6 percent over the previous year. Its ratio to the total amount of research expenses was 73.2 percent (Figure 2.1.5). The emphasis of research activity by companies is placed in research and development associated with the development of new products and new manufacturing methods and or the improvement of conventional techniques. Of research expenses spent by companies, 72.1 percent is designated for such activities (Figure 2.1.12).

The number of companies (capital of more than ¥5 million) which conducted research was 14,000 in 1985. Under the classification of type of industry, the manufacturing industry occupied 92.8 percent, followed by the construction industry with 6.1 percent. Among the manufacturing industry totals, the machine industry accounted for 15.4 percent, showing the largest ratio (Figure 2.1.24).

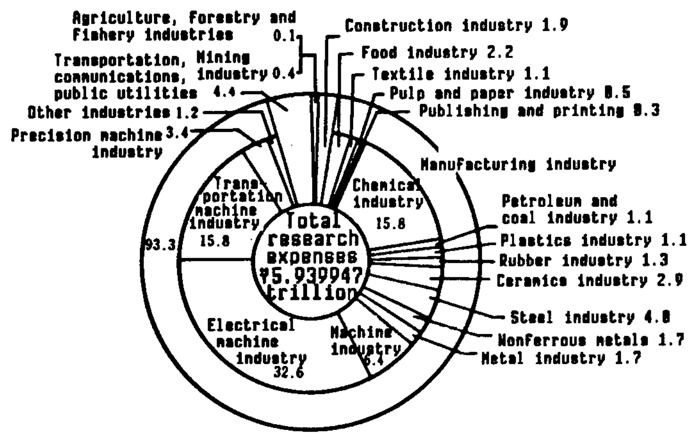
When the proportion of research expenses classified by the type of industry is examined, the manufacturing industry accounts for the greater part, i.e., 93.3 percent, followed by transportation, communications, and public utilities, sharing 4.4 percent. Among the manufacturing industry figures, the electric machine industry occupies 32.6 percent, while the chemical and transportation machine industries share 15.8 percent. These three industries account for 64.1 percent of research expenses of all industries (Figure 2.1.24). The average rate of increase in research expenses spent by these three industries for the past 10 years (1975-1985) is 17.1 percent for the electric machine industry, 12.4 percent for the transportation machine industry, and 11.3 percent for the chemical industry.

The ratio of research expenses to sales is thought to be an index indicative of research activity occurring in an enterprise. When this ratio becomes larger, it means that the company looks upon research as important for the future. The ratio of research expenses spent by all companies in Japan to the total sales was 2.31 percent in 1985. This figure is the highest attained so far. When the ratio is classified by type of industry, the electric machine industry had the highest (5.1 percent) in 1985. Regarding other industries, the precision machine industry had 4.49 percent, the chemical industry had 3.79 percent, and the transportation machine industry had 2.9 percent (Figure 2.1.25). Regarding research expenses for expenditures in companies, the ratio of personnel expenses gradually increased beginning in 1970, reaching 51.9 percent in 1976. After 1977 it decreased, becoming 40.7 percent in 1985 (Figure 2.1.26).

(1) Number of companies conducting research



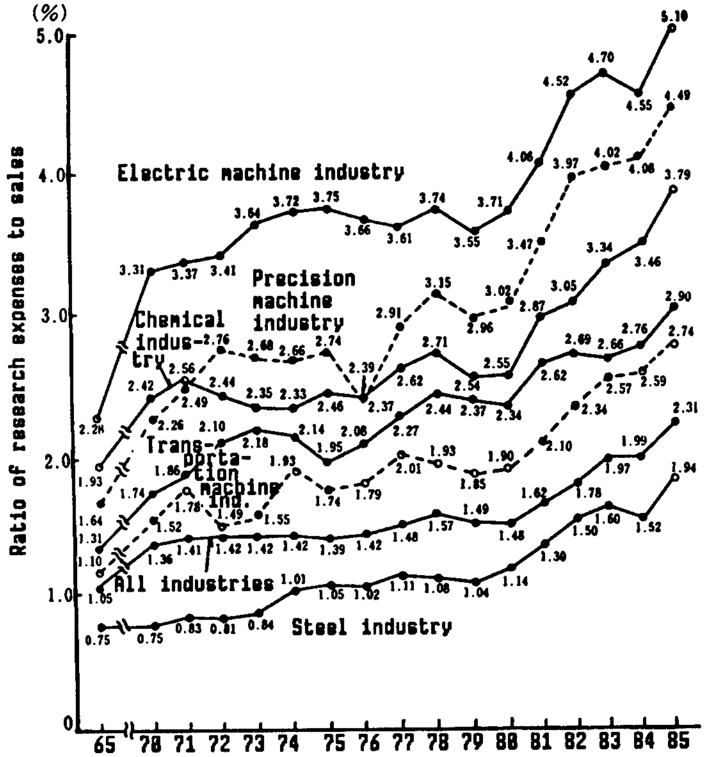
(2) Research expenses



Note: 1. Companies with capital of more than ¥500 million are included in the survey.
2. Research expense includes expenditures used for a company.
3. Figures indicate percent of the total.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

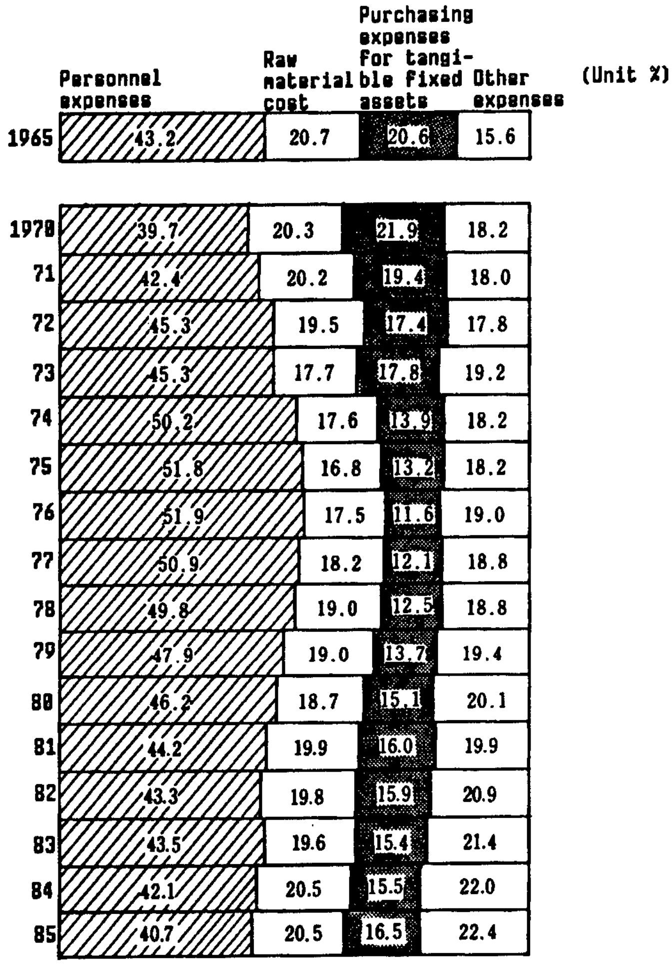
Figure 2.1.24. Number of Companies Conducting Research by Type of Industry and Proportion of Research Expenses



Note: 1. Ratio of research expenses spent for in-house research activity to sales is used.
2. Special corporations are excluded.

Source: Generated from "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.25. Change in Ratio of Research Expenses to Gross Sales in Major Industries

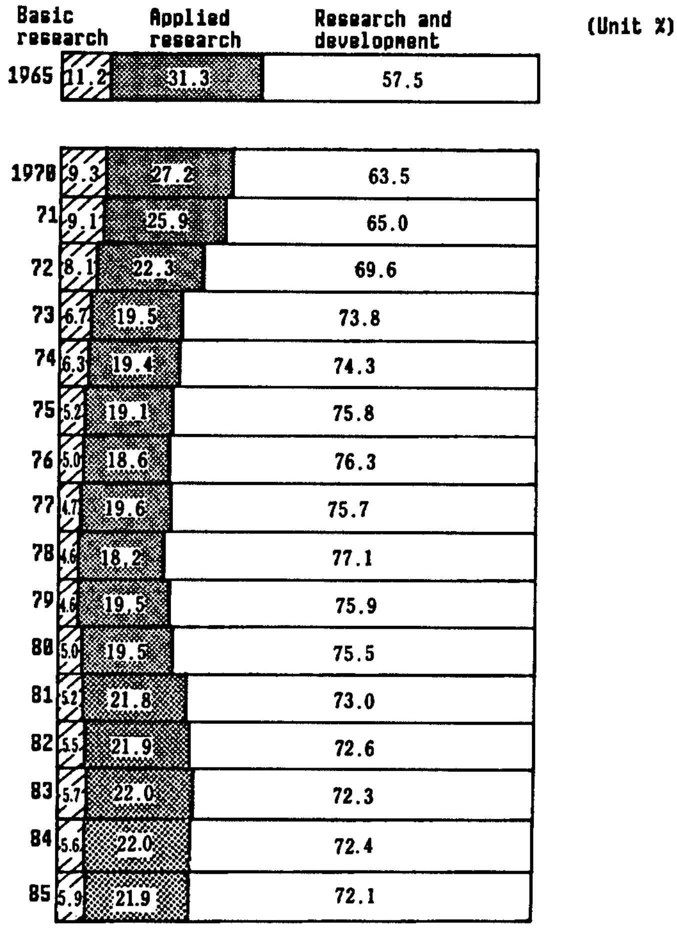


Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.26. Change in Ratio of Research Expenses of Private Companies by Item

When a change in the proportion of research expenses of companies by character of work is examined, it is seen that the ratios of basic research and applied research consistently decreased, and those of research and development increased from 1965 through 1975. These ratios became stable in the second half of the 1970s. The ratios of basic and applied research gradually increased in the first half of the 1980s. In 1985, the ratios were 5.9 percent, 21.9 percent, and 72.1 percent for basic research, applied research and research and development, respectively (Figure 2.1.27).

Research expenses per researcher in companies was ¥25.7 million in 1985, showing an increase of 12 percent over the previous year. When the research expenses per researcher is categorized by type of industry, it is seen that transportation, communications, and public utilities spent the



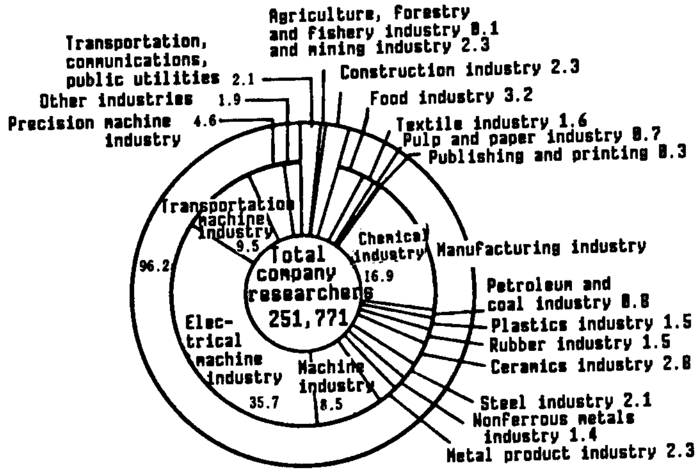
Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.27. Change in Ratio of Research Expenses of Private Companies by Character of Work

largest amount, ¥55.95 million. This was followed by the mining industry, which spent ¥29.21 million, the manufacturing industry, spending ¥25.26 million, the agriculture, forestry and fishery industries, spending ¥25.06 million, and the construction industry, spending ¥18.17 million. Within the manufacturing industry, the steel industry spent ¥45.55 million, which was the largest research expenditure per researcher. Next came the transportation machine industry, spending ¥42.29 million, and then the petroleum-coal products industry, spending ¥39.05 million (Figure 2.1.29).

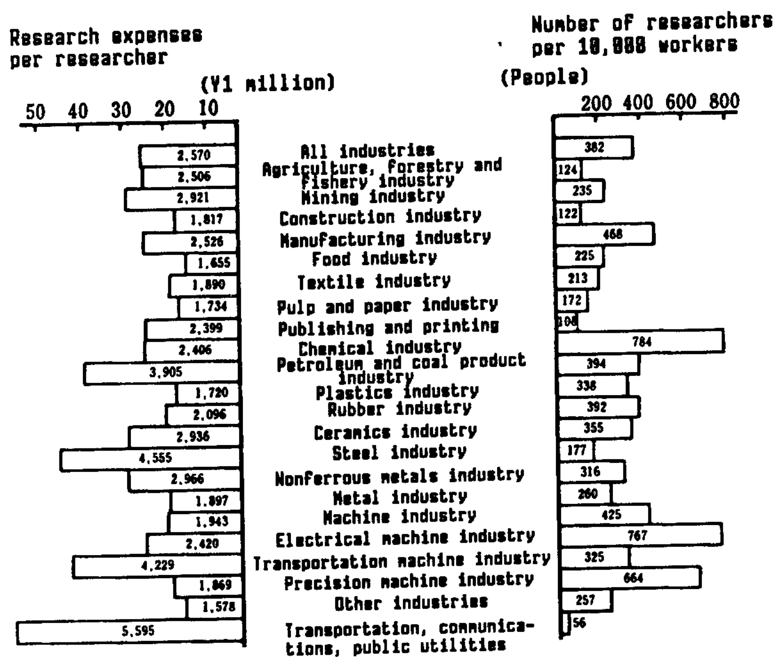
(ii) Manpower for research in companies

The number of researchers in companies as of 1 April 1986 was 252,000. This was an increase of 8.9 percent over the 231,000 of the previous year. When this figure is classified into types of industry, 240,000 researchers belong to the manufacturing industry, comprising 95.2 percent of the total. Within the manufacturing industry, the electric machine industry has 90,000 researchers (35.7 percent of the total), while the chemical industry has



Note: 1. Company with capital of more than ¥5 million subjected.
2. As of 1 April 1986.
3. Figure indicates a percent of the total number.
Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.28. Proportion of Researchers in Private Companies by Type of Industry



Note: 1. The calculation of "research expenses per researcher" is based upon the number of researchers as of 1 April 1985 and research expenses in 1985.
2. "The number of researchers per 10,000 workers" is as of 1 April 1986.
Source: Generated from "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.29. Research Expenses Per Researcher and Number of Researchers Per 10,000 Workers in Companies

43,000 researchers (16.9 percent). The number of researchers for both the chemical and electric machine industries exceeds more than half of the total number of researchers (Figure 2.1.28). Although the average number of researchers per 10,000 employees in a company is 382, that of the manufacturing industry is 468. This is a remarkably high number. When classified by type of industry, it is seen that the chemical industry has 784 researchers, the electric machine industry as 767, the precision machine industry has 664, the machine industry has 425, the petroleum-coal industry has 394, and the rubber industry has 392 researchers. These industries have more researchers than average (Figure 2.1.29).

When the number of researchers is categorized by area of expertise, researchers in engineering account for 61.1 percent, followed by researchers in sciences at 27.1 percent, health at 3.2 percent, and agriculture at 3 percent. Among the engineering fields, electric/communications and machine/ship/aviation are the major areas. Chemistry is the major science field. The number of researchers belonging to these three fields accounts for three-fourths of the total number of researchers in companies (Figure 2.1.30).

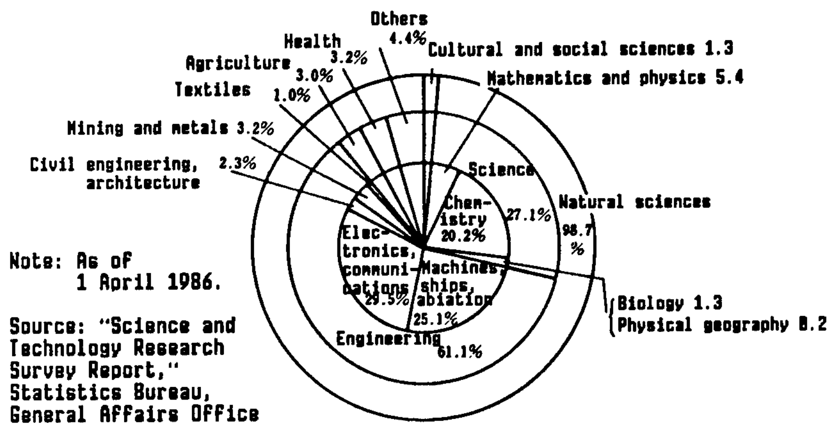


Figure 2.1.30. Proportion for Number of Researchers in Private Companies by Specialty (1986)

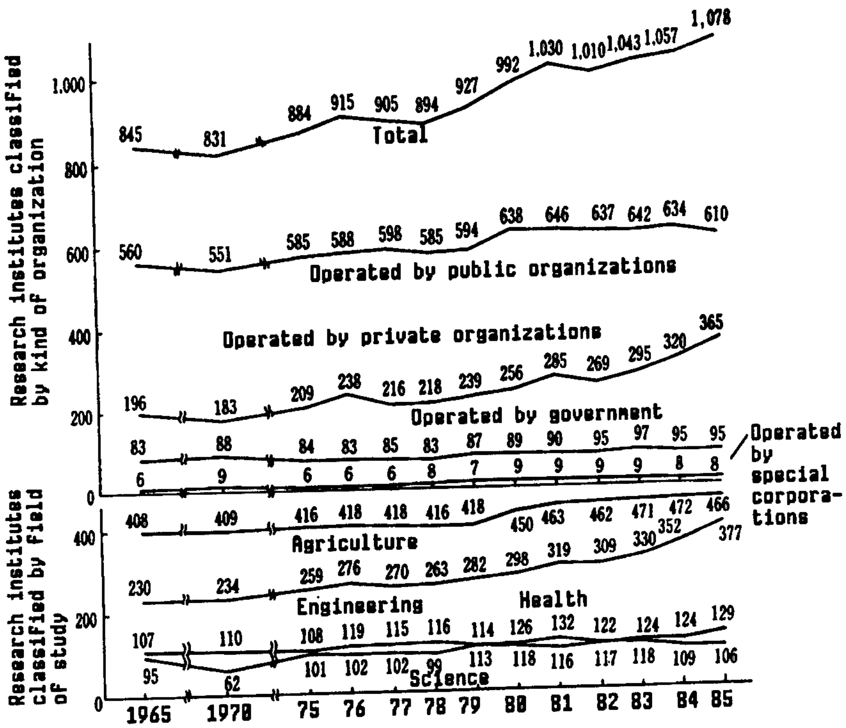
(2) Research Activity of Research Institutes

Research institutes are conducting leading and large-scaled research such as of nuclear and space development, indispensable research for agriculture, forestry and fishery industries, and for small-to-medium enterprises which are not able to carry out actual research by themselves due mainly to their small-scale management, and research related to local industries which support the growth of the local economy. Since research institutes deal with the areas for which private organizations find research and development difficult to handle, the management of the research institutes and the burden of research expenses are mainly undertaken by the government and local public organizations.

(i) Research expenses of research institutes

The amount of research expenses in research institutes was ¥1,101 billion in 1985. This was an increase of 12.8 percent over the previous year. This amount accounts for 13.6 percent of the total research expenses spent in Japan (Figure 2.1.5).

Of the research expenses spent by the research institutes, 72.5 percent was charged to the government, while only 27.3 percent was shouldered by private companies. This is because the government supports most of the research institutes operated by the government, public organizations, and special corporations, and 18.4 percent of the private research institutes.



Note: There are 5 and 16 research institutes categorized as "others" in 1965 and 1970, respectively.

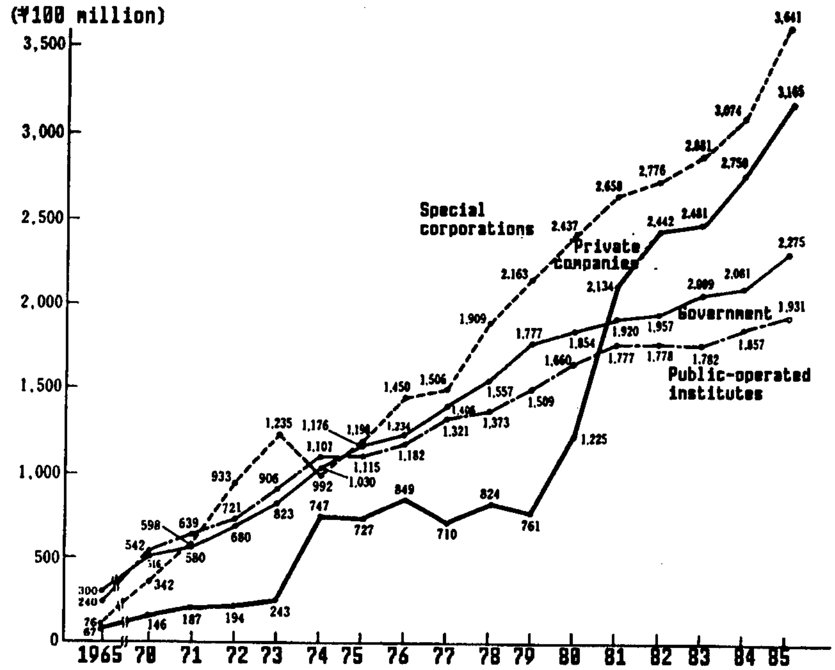
Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Office

Figure 2.1.31. Change in Number of Research Institutes by Kind of Organization and Field

Regarding the number of research institutes which actually conducted research and development in 1985, there was no change in the number operated by the government and special corporations. However, there was a decrease of 24 publicly-operated institutes, and an increase of 45 privately-operated institutes. As a result, the ratios of the number of research institutes by kind of organization operating them in 1985 was 8.8 percent by the government, 56.6 percent by public organizations, 33.9 percent by private organizations, and 0.7 percent by special organizations.

The ratios of the number of research institutes classified by field of study were 43.2 percent for agriculture, 35 percent for engineering, 9.8 percent for science, and 12 percent for health (Figure 2.1.31).

The research institutes operated by the government mainly conduct research associated with engineering (40 percent) and agriculture (30.5 percent), while those operated by public organizations deal mostly with agriculture (61.3 percent), and engineering (21.8 percent). In the case of the privately-operated research institutes, the ratio of engineering is large (55.9 percent), followed by 17 percent for agriculture. Most research institutes operated by special corporations conduct research related to science and engineering.



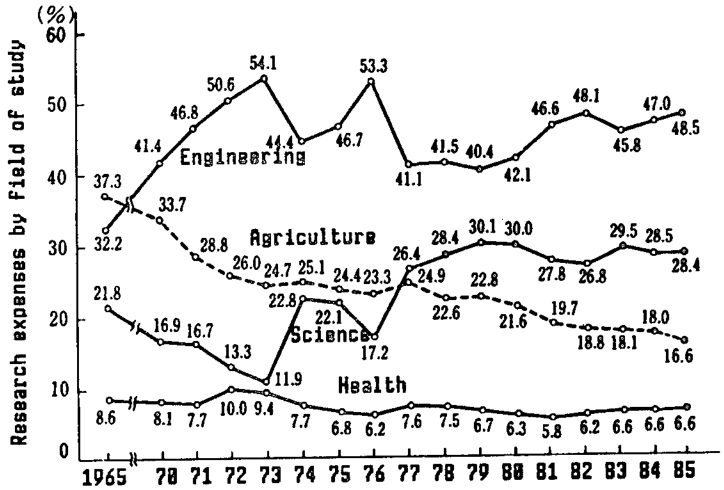
Note: The reason for the research expenses of special corporations decreasing and those of private companies suddenly increasing comes from the fact that the technology research union, under the mining industry technology research union law, was classified as a private company instead of a special corporation.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.32. Change in Research Expenses Spent by Research Institutes

The contributions of each organization to the research expenses of research institutes in 1985 were ¥227.5 billion (20.7 percent) by the government, ¥193.1 billion (17.5 percent) by public companies, private companies ¥316.5 billion (28.7 percent), and ¥364.1 billion (33.1 percent) by special corporations (Figure 2.1.32).

When the proportion of research expenses in research institutes by field of study is examined, engineering accounts for 48.5 percent, followed by



Note: Regarding health, about 1 percent of research expenses in natural sciences, excluding engineering, agriculture, science, and health, was included in the data prior to 1969.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.33. Change in Proportion of Research Expenses in Research Institutes by Field

science for 28.4 percent, agriculture for 16.6 percent, and health for 6.6 percent (Figure 2.1.33).

When research expenses spent by research institutes are itemized, it is characteristic that the ratio of personnel expenses is very large for research institutes operated by public organizations. On the other hand, the ratio of purchasing expenses for tangible fixed assets becomes large in special corporations. This is because nuclear development and space development, which need large-scale facilities and instruments, are included in this ratio (Figure 2.1.34).

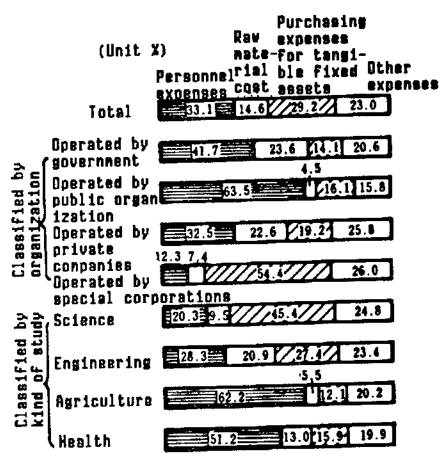


Figure 2.1.34. Proportion of Research Expenses in Research Institutes by Item of Expenditure (1985)

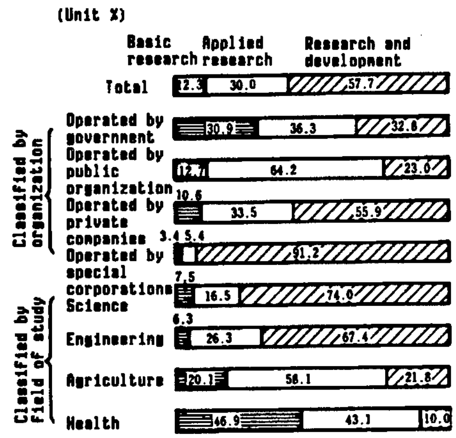


Figure 2.1.35. Proportion of Research Expenses in Research Institutes by Kind of Work (1985)

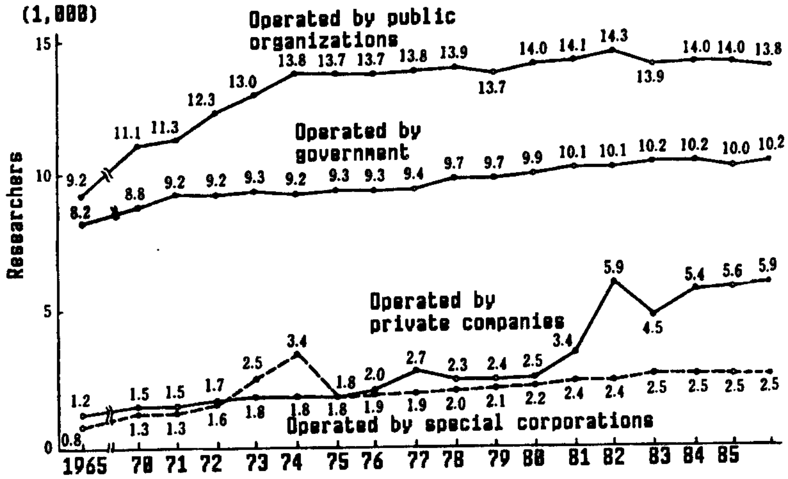
The proportion of research expenses in research institutes categorized by character of work indicates that the research institutes operated by the government deal mainly with basic research. The ratio of applied research becomes large for research institutes operated by public organizations. It is expected that the ratio of research and development work is very large for special corporations. From the viewpoint of classification by field of study, basic research and applied research are greatly focused on by research institutes which conduct studies related to the preservation of health. The ratio of applied research becomes large in research institutes dealing with agriculture, while that of research and development is large in those conducting studies related to science engineering (Figure 2.1.35).

The average research expenses per researcher for research institutes was ¥34.23 million, which was an increase of 12.2 percent over the previous year. When research expenses per researcher is classified by type of organization, it is seen that a research institute operated by a special corporation has the greatest research expenses, i.e., ¥146.39 million, followed by that operated by a private company which has ¥56.02 million, that operated by the government which as ¥22.66 million, and that operated by public organizations which as ¥13.8 million.

(ii) Manpower for research institutes

The total number of researchers engaged in research institutes as of 1 April 1986 amounted to 32,000, an increase of 0.9 percent over the previous year.

The numbers of researchers were classified by type of organization. The results indicate that 10,000 researchers (31.3 percent of the total number of researchers in all research institutes), an increase of 1.3 percent over the previous year, worked in research institutes operated by the government, 14,000 researchers (42.6 percent), a decrease of 1.1 percent, worked in the institutes operated by public organizations, 6,000



Note: As of 1 April for each year.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.36. Change in Number of Researchers in Research Institutes by Type of Organization

researchers (18.2 percent), an increase of 4.5 percent, worked in those operated by private companies, and 3,000 researchers (7.8 percent), an increase of 2.3 percent, worked in those operated by special corporations. The number of researchers in research institutes operated by the government and public organizations accounts for 74 percent of the total (Figure 2.1.36).

The number of researchers in research institutes classified by field of study was examined. The ratio of researchers in engineering was 37.9 percent. This was followed by agriculture at 34.9 percent, science at 16 percent, and health at 11.2 percent (Table 2.1.37).

Table 2.1.37. Number of Researchers in Research Institutes by Type of Organization and Field (1986) (Unit: person)

Classified by type of organization	Total	Classified by field of study: Science	Engineering	Agriculture	Health
Total	32,459	5,203	12,296	11,336	3,624
ratio (percent)	(100.0)	(16.0)	(37.9)	(34.9)	(11.2)
Operated by government	10,169	1,347	4,535	3,184	1,103
Operated by public organizations	13,843	1,253	3,365	7,578	1,647
Operated by private companies	5,902	517	3,995	516	874
Operated by special corporations	2,545	2,086	401	58	--

Note: As of 1 April 1986.
Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

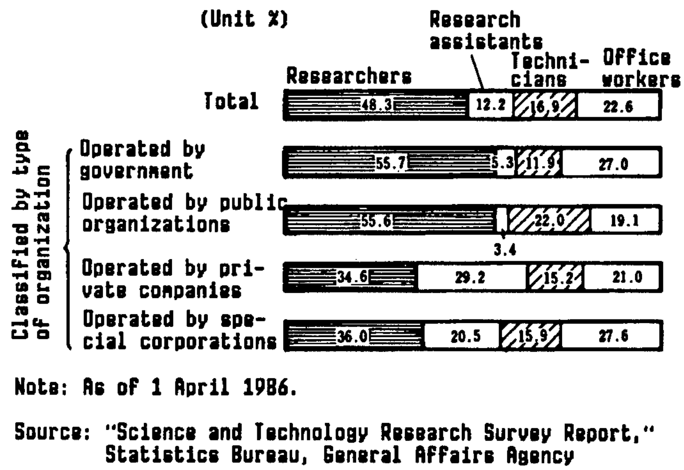


Figure 2.1.38. Proportion of Persons Engaged in Types of Research Work in Research Institutes (1986)

The number of employees engaged in research and its related work totals 67,000. Of these, researchers number 32,000, accounting for 48.3 percent of the total. Research assistants number 8,000 (12.2 percent), technicians 11,000 (16.9 percent), and office workers 15,000 (22.6 percent). When these numbers are classified by type of organization, the ratio of researchers to employees is high in the research institutes operated by the government and public organizations. The institutes operated by private companies and special corporations feature a relatively high ratio of research assistants to employees (Figure 2.1.38).

(3) Research Activity of Universities

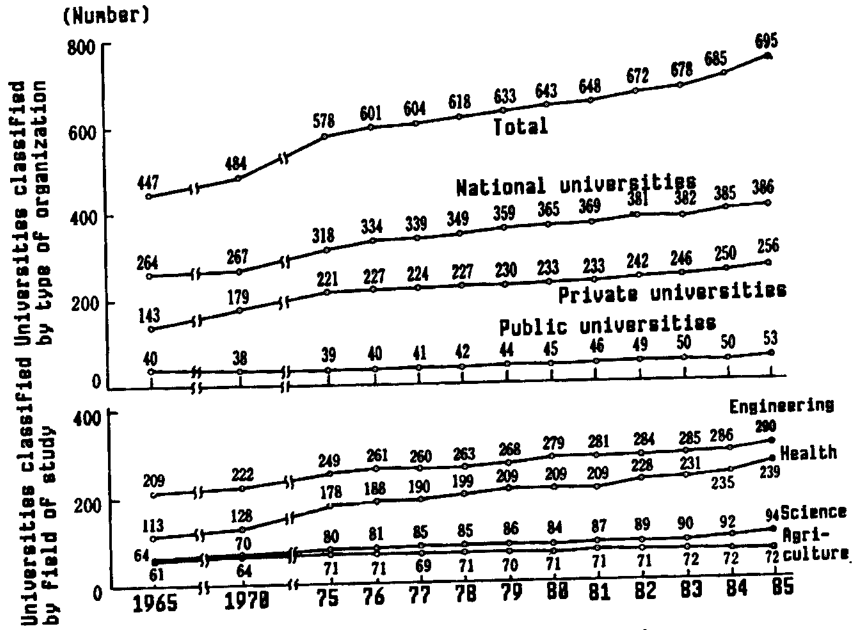
Universities not only accept the important mission, as higher education organizations, to educate people engaged in research work, but as research institutes, must also conduct extensive academic study aimed at the "investigation of truth." Therefore, universities play an important role in the area of basic research, which is the basis for the development of new technologies.

There are 695 universities in the area of natural science, which is an increase of 1.5 percent over the past year. When the number of universities is classified by type of organization, national universities account for 55.5 percent of the total, public universities for 7.6 percent, and private universities for 36.8 percent (Figure 2.1.39).

(i) Research expenses of universities

Research expenses spent by universities totaled ¥1.0754 trillion in 1985. This figure was an increase of 1.1 percent over the previous year (Figure 2.1.5).

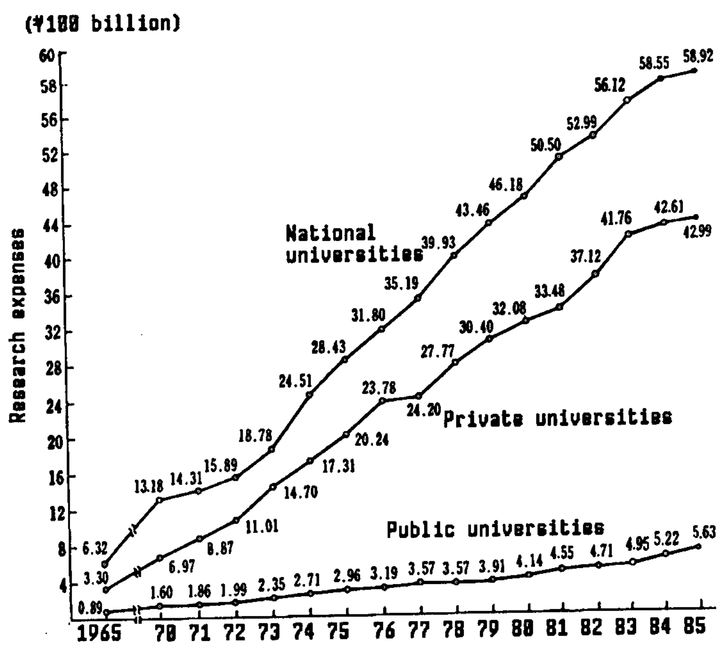
When the research expenses of universities is categorized by the kind of organization, it is observed that national universities spent



Note: The unit of a university surveyed is a department.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.39. Change in Number of Universities by Kind of Organization and Field of Study

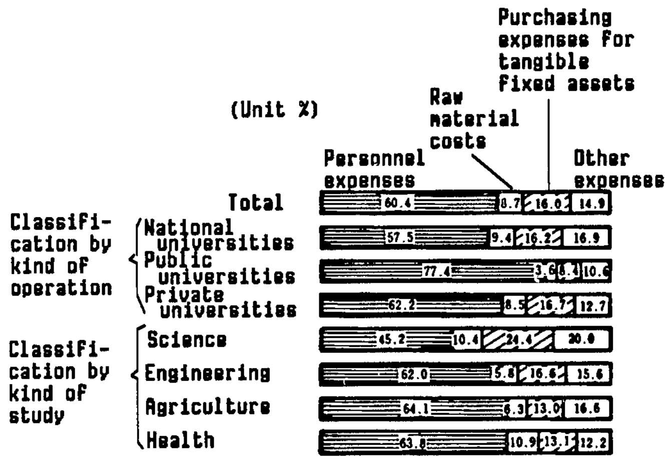


Source: "Science and Technology Research Survey Reoprt," Statistics Bureau, General Affairs Agency

Figure 2.1.40. Change in Research Expenses in Universities by Kind of Organization

¥589.2 billion (54.8 percent), public universities spent ¥56.3 billion (5.2 percent), and private universities spent ¥429.9 billion (40 percent). The national universities used more than half of the total expenditures. Increasing ratios over the previous year are 0.6 percent for national universities, 7.9 percent for public universities, and 0.9 percent for private universities (Figure 2.1.40).

The classification of research expenses in universities by field of study results in ¥162 billion (15.1 percent) being used for science, ¥371.4 billion (34.5 percent) used for engineering, ¥85.3 billion (7.9 percent) used for agriculture, and ¥456.7 billion (42.5 percent) used for the preservation of health.

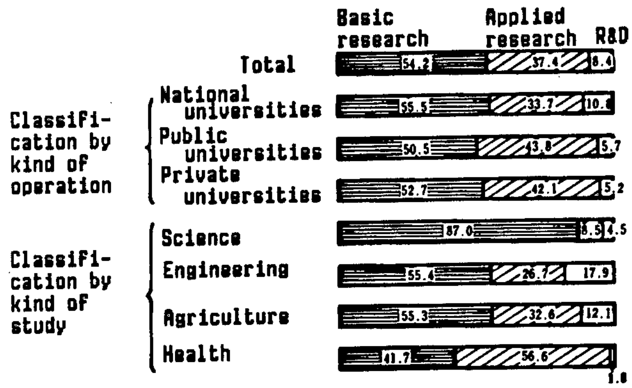


Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.41. Proportion of Research Expenses in Universities Categorized by Item of Expenditure (1985)

When research expenses of universities are itemized by kind of expenditure, it is seen that the ratio of personnel expenses to the total expenditure is higher than that of companies and/or research institutes. In 1985, it was 60.4 percent. It reached 77.4 percent for public universities. Next, the expenses are classified by field of study. The percentage of personnel expenses becomes large in engineering, agriculture, and health. The percentage of purchasing expenses for tangible fixed assets is larger for science (Figure 2.1.41). When the proportion of research expenses for a type of work is examined, that for basic research exceeds 50 percent, while that for research and development is low (Figure 2.1.42).

With respect to research expenses per researcher, there has been a decrease of 2.2 percent, from ¥9.32 to 9.11 million, on the average. When research expenses per researcher are calculated so that the total is divided only by the number of staff who are central to research activity, it becomes ¥14.1 million for all universities. This figure becomes ¥14.86 million for national universities, ¥11.3 million for public universities, and ¥13.57 million for private universities.

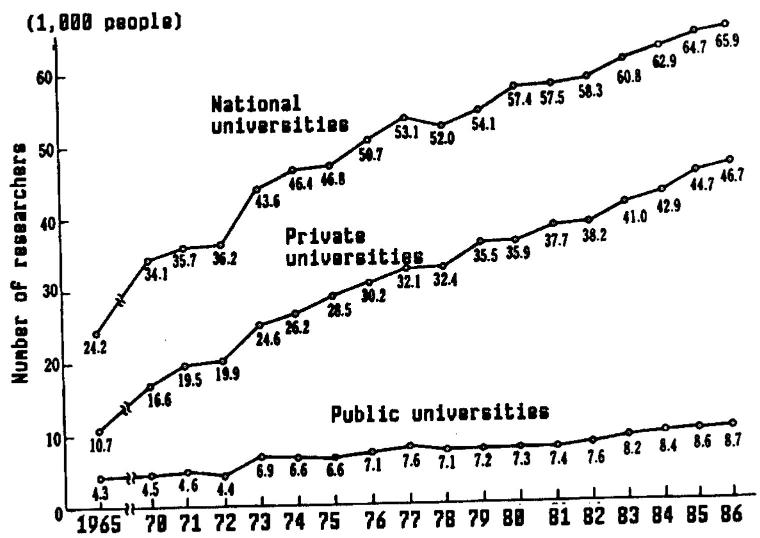


Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.42. Proportion of Research Expenses in Universities by Character of Work (1985)

(ii) Manpower for research in universities

The number of researchers in universities as of 1 April 1986 had reached 121,000. This is an increase of 2.8 percent over the previous year. Changes in the number of researchers in universities by the kind of organization have increased by 2 percent for national universities, 1.1 percent for public universities, and 4.3 percent for private universities (Figure 2.1.43).

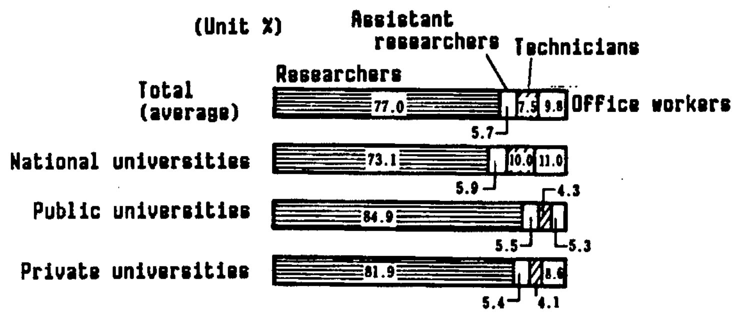


Note: 1. As of 1 April each year.

2. The reason for the number of researchers suddenly increasing in 1973 was that medical staff was included beginning in 1973.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Report

Figure 2.1.43. Changes in Number of Researchers in Universities by Kind of Organization

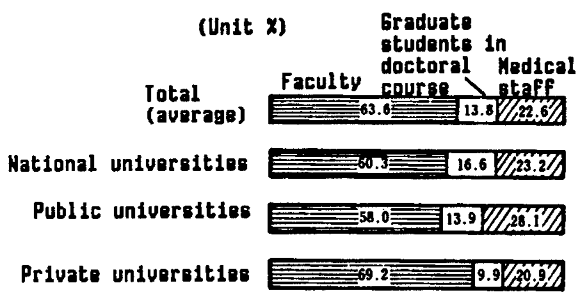


Note: As of 1 April 1986.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.44. Proportion of Persons Engaged in Research in Universities (1986)

The number of employees engaged in research and its related work in universities totals 157,000. Among them, 121,000, or 77 percent, is accounted for by researchers. The number of research assistants is 9,000, accounting for 5.7 percent, that of technicians is 12,000, accounting for 7.5 percent, and that of office workers is 15,000, accounting for 9.8 percent (Figure 2.1.44).



Note: As of 1 April 1986.

Source: "Science and Technology Research Survey Report," Statistics Bureau, General Affairs Agency

Figure 2.1.45. Proportion of Researchers in Universities (1986)

Researchers can be classified into faculty members, graduate students in doctoral courses, medical staff, etc. When a comparison of these classifications among national, public, and private universities is made, the percentage of graduate students in doctoral courses is relatively large in national universities. On the other hand, the percentage of medical staff members is relatively large in public universities. The percentage of faculty members is large, and that of graduate students in doctoral courses low, in private universities (Figure 2.1.45).

20149/9365

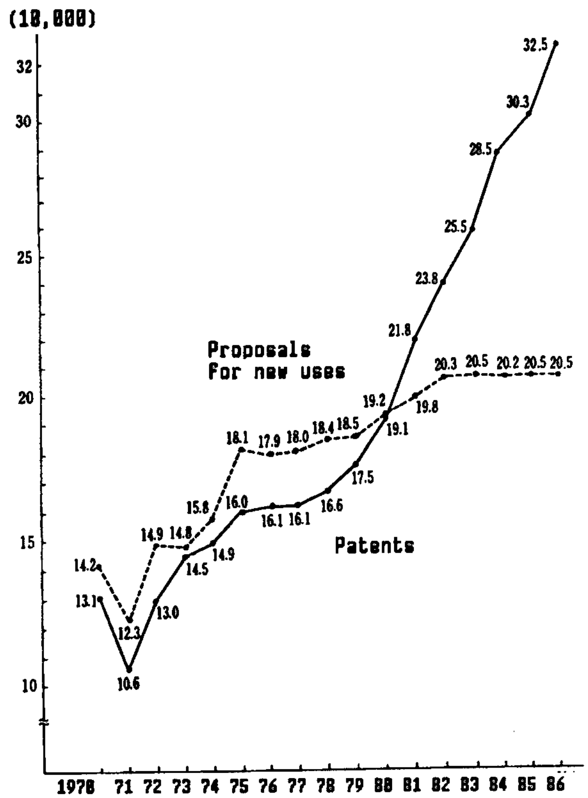
Trends in Patent Applications

43063506d Tokyo KAGAKU GIJUTSU HAKUSHO in Japanese 10 Feb 88 pp 171-177

[Text] [Chapter 2] 2. Patent Applications

(1) Trends in Japanese Patent Applications

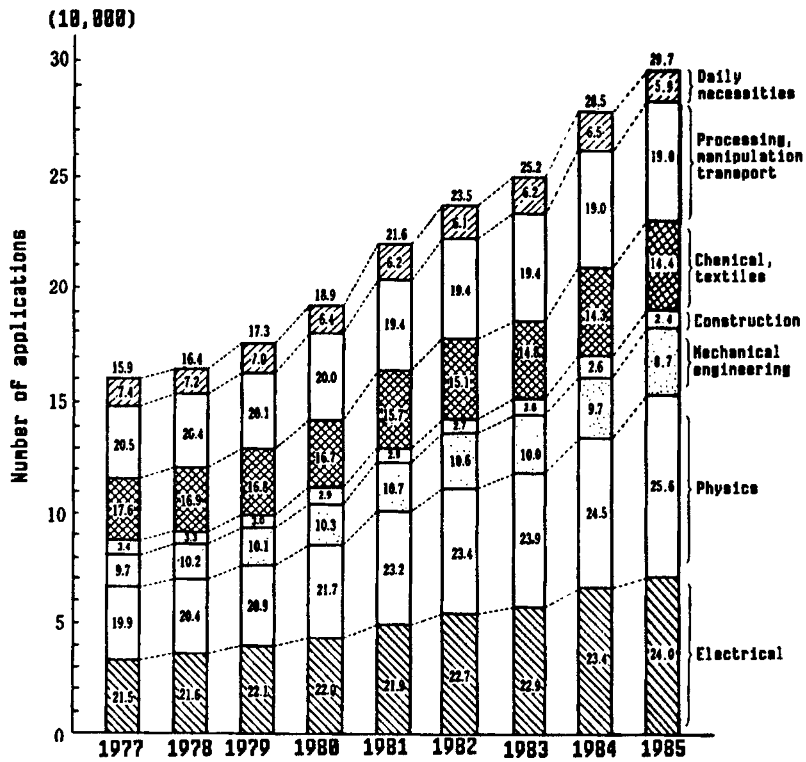
Reflecting improved levels of technology and a lively enthusiasm for technological development, the number of applications for patents and proposals for new uses in Japan is on the rise. In FY 1986 the total number of patents and proposals for new uses came to 529,953, a 3 percent increase over the previous year. In particular, patent applications alone came to 325,173, a 5.2 percent increase over the previous year and a high growth level. In contrast, the number of applications involving new uses was 204,780, an 0.2 percent drop from the previous year--a continuation of the flat trend since FY 1982 (Figure 2.3.9).



Source: Patent Office "Patent Office Annual Report"

Figure 2.3.9. Trends in Number of Applications for Patents and New Uses

Looking at the number of patent applications broken down into various technical areas, in 1985[1] there were 75,933 in physics (25.6 percent of total), 71,028 in the electrical area (24 percent), and 56,473 in processing/manipulating/transporting areas 919 percent) (Figure 2.3.10). comparing the number of patent applications in various fields to the previous year, in physics there was a 9.8 percent increase, in the electrical area there was a 5.3 percent increase, in chemical/metallurgical/textiles there was a 6 percent increase, and in processing, manipulating/transporting there was a 5.3 percent increase, for an average increase in all areas of 5.3 percent, reflecting the above-noted growth. In contrast, there was a 6 percent decrease in the field of mechanical engineering, a 3.1 percent decrease in daily necessities, and a 0.4 percent decrease in the construction area.

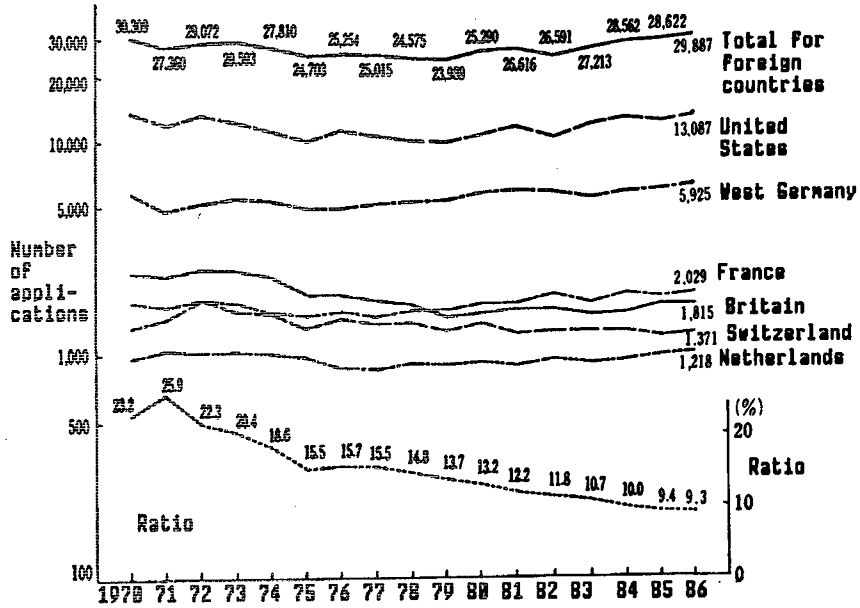


Note: 1. Figures refer to percent of total.
2. Figures given for applications which have been categorized.

Source: Patent Office "Patent Office Annual Report"

Figure 2.3.10. Trends in Number of Patent Applications by Area

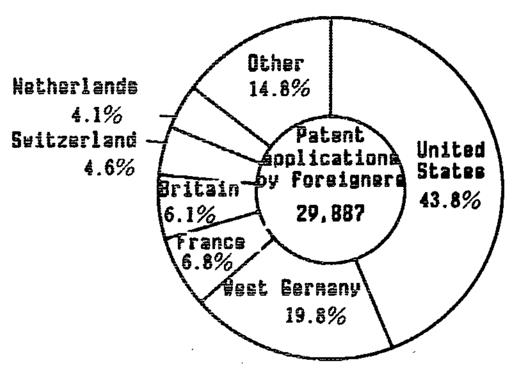
[1] It takes approximately 1 year for a patent application to be assigned a category.



Source: Patent Office "Patent Office Annual Report"

Figure 2.3.11. Trends in Patent Applications in Japan by Foreigners

Patent applications in Japan by foreigners have been steady for the last few years. In 1986, there were 29,887, a 4.4 percent increase over 1985 (Figure 2.3.11). When we look at these broken down by the nationality of the applicant, 43.8 percent come from the United States, followed by West Germany (19.8 percent), France (6.8 percent), Britain (6.1 percent), and Switzerland (4.6 percent) (Figure 2.3.12).



Source: Patent Office "Patent Office Annual Report"

Figure 2.3.12. Percentage of Patent Applications by Foreigners, by Country (1986)

Looking at the percentage of foreign applications in 1985 by sector, the highest was the chemical/metallurgical/textile area (17.8 percent), followed by daily necessities (12.6 percent), mechanical engineering (10.2 percent), and processing/manipulating/transporting (8.7 percent).

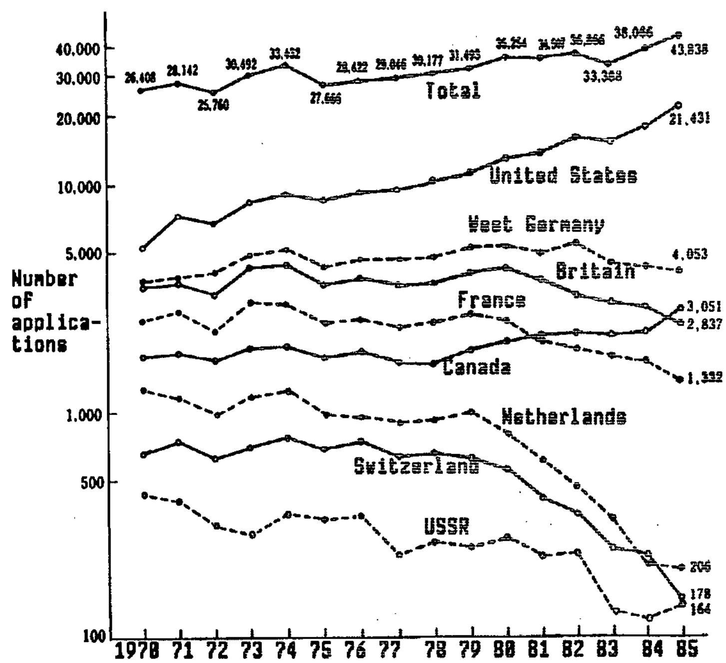
Table 2.3.13. Trends in Number of Patent Applications by Foreigners, by Area (in percent)

Item \ Year	1978	1979	1980	1981	1982	1983	1984	1985
Daily necessities	15.9	15.6	16.1	15.3	15.1	15.5	14.2	12.6
Processing, manipulating, transport	15.5	14.5	13.3	13.2	11.5	10.6	10.1	8.7
Chemicals, metallurgy, textiles	25.6	23.9	23.7	23.3	21.0	20.2	19.4	17.8
Construction	11.1	10.9	10.7	10.2	8.9	8.3	8.2	6.4
Mechanical engineering	17.3	16.9	15.3	13.4	11.7	11.5	10.6	10.2
Physics	11.0	10.2	9.2	8.0	7.5	7.1	6.3	5.3
Electrical	8.8	8.5	8.2	7.7	6.9	6.7	6.1	5.2
Total	14.9	14.1	13.3	12.	11.	10.6	9.8	8.6

Source: Patent Office "Patent Office Annual Report"

(2) Japan's Patent Applications in Foreign Countries

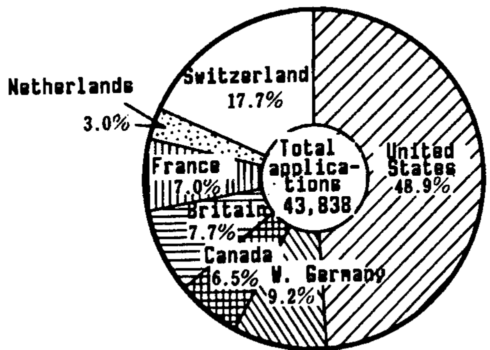
In 1985, the number of patent applications by Japan in foreign countries came to 43,838, 5,772 more than 1984 (15.2 percent increase) (Figure 2.3.14).



Source: WIPO (Industrial Property Statistics)

Figure 2.3.14. Trends in Number of Patent Applications by Japanese in Foreign Countries

Broken down by country, 48.9 percent were in the United States, followed by West Germany (9.2 percent), South Korea (7.7 percent), Canada (7 percent), and Britain (6.5 percent) (Figure 2.3.15).



Source: WIPO (Industrial Property Statistics)

Figure 2.3.15. Breakdown of Foreign Patent Applications by Japanese (1985)

Furthermore, of the patent applications in major countries, the ratio of such on the part of Japanese is increasing in the United States and Canada (Table 2.3.16).

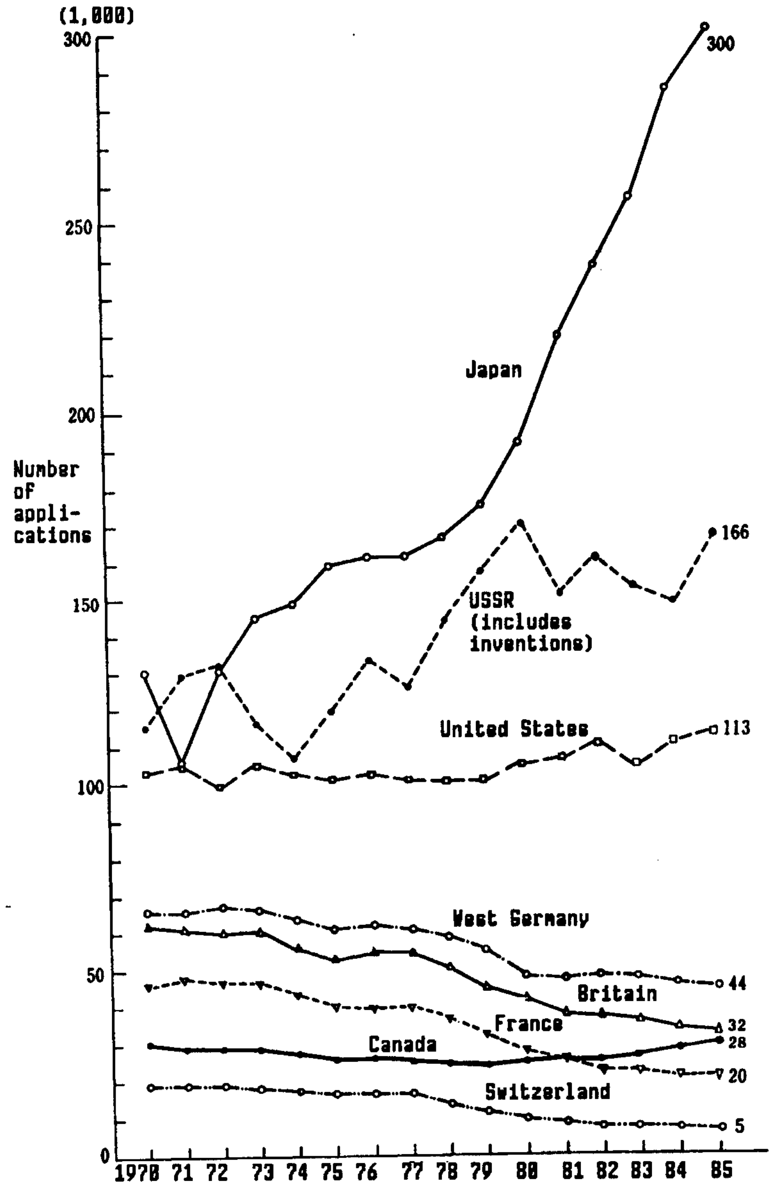
Table 2.3.16. Trends in Percentage of Patent Applications in Foreign Countries Coming From Japan

Country	1970	1975	1980	1981	1982	1983	1984	1985
United States	5.1	8.5	12.4	13.2	14.7	15.4	16.6	19.0
West Germany	5.8	7.2	10.8	10.6	11.3	9.3	9.4	9.2
Canada	5.8	6.8	8.1	8.7	9.7	9.2	9.9	11.1
Britain	5.8	6.8	10.1	9.8	9.8	9.5	9.5	8.9
France	5.3	6.0	8.9	8.8	8.3	7.7	7.4	6.8
Netherlands	6.5	6.4	10.7	9.8	9.2	8.5	5.8	5.7
Switzerland	3.4	4.1	5.7	5.2	5.2	4.3	3.9	3.3

Source: WIDO, "Industrial Property Statistics."

(3) Patent Application Trends in Major Countries

Looking at the number of patent applications in major countries, Japan ranks at the top, with 320,089 in 1985. Japan is followed by the Soviet Union (166,484, including inventions)), the United States (112,623), West Germany (43,940), and Britain (31,965) (Figure 2.3.17).



Source: Patent Office "Patent Office Annual Report"

Figure 2.3.17. Trends in Number of Patent Applications in Major Countries

20149/9365

Governmental Tasks, Policies, Appropriations

43063506e Tokyo KAGAKU GIJUTSU HAKUSHO in Japanese 10 Feb 88 pp 219-271

[Article by editor]

[Text] **Section 3. Chapter 1. Scientific and Technological Policies of Japan**

The promotion of science and technology is a basis for the development of the social economy and is instrumental in vitalizing industrial activities and improving living standards and welfare. Recently, therefore, it has become increasingly important internationally as well. Japan, in particular, which lacks natural resources and must seek the foundation of its existence in intellectual creativity, which can be termed its only resource, expects much of new developments in science and technology as its hope for the future. Therefore, further promotion of science and technology is an extremely important policy task for Japan.

It is especially important for Japan to create original, innovative technologies that can contribute to the progress and development of mankind, and for this purpose it is necessary for Japan to strengthen its basic research.

The roles played by Japan in the international community have been expanding in recent years, and it is becoming important for Japan to make international contributions toward science and technology in line with this trend. Under these circumstances, the government, based on a recommendation by the Science and Technology Council, which is the highest deliberative organ for scientific and technological policies, at a Cabinet conference in March last year, determined its "general principles for scientific and technological policies," setting out the fundamentals of its science and technology policies for the future. The principal pillars of these policies are: 1) promotion of science and technology, with an abundance of creativity, focused on the strengthening of basic research; 2) development of science and technology with importance attached to international applications; and 3) harmonizing science and technology with man and society.

In line with these basic policies the government is working to develop comprehensive, flexible science and technology policies from a long-range point of view.

In regard to the strengthening of basic research, the government is promoting creative, advanced research, under the direction of universities, by such means as furnishing subsidies for scientific research, strengthening basic research at national experimental and research organizations, utilizing budgetary appropriations for the promotion and coordination of science and technology, and promoting an "international frontier research system" designed to aid the Institute of Physical and Chemical Research in unearthing new knowledge to provide a key to realizing technological innovations in the 21st century, and a "creative science and

technology promotion system" designed to aid the Research and Development Corporation in creating innovative technologies for the future.

As for the development of science and technology with importance attached to international applications, the government is positively promoting the exchange of information, exchange of experts, joint research, etc., by consolidating frameworks for such matters as agreements for science and technology cooperation with foreign countries.

Furthermore, the government enacted a research exchange promotion law in May 1986, thereby eliminating a legislative bottleneck in carrying out international joint research, etc. Also, it has been working to consolidate Japan's research structure in a form that is internationally open for both capable researchers and research information (employing foreign researchers under the creative science and technology promotion system, inviting foreign researchers to universities, national experimental and research organizations, etc., furnishing science and technology information to foreign countries, etc.).

1. General Principles of Science and Technology Policies

(1) Circumstances Leading to Policy Formulation

In the "recommendation concerning measures to promote an administrative reform" made by the Provisional Administrative Reform Promotion Deliberation Council dated 22 July 1985, it was pointed out that "general principles of scientific and technological policies" should be determined by the Cabinet as a general policy for preferential and efficient promotion of Japanese science and technology. In response to this recommendation, it was decided that "general principles of policies for science administration" be determined at a Cabinet conference within FY 1985 in accordance with the Cabinet decision on "immediate measures to materialize administrative reform" dated 24 September 1985.

With this situation in mind, inquiry No 12 was addressed by the Science and Technology Council under the title "On General Principles of Scientific and Technological Policies." Taking into account the contents of recommendation No 11, which laid down the basic principles for the promotion of science and technology during the next 10 years or so and predictable changes after that in science and technology situations, on 3 December 1985 the Council formulated basic principles of policies for the promotion of science and technology, which should be realized through efforts made on the administrative level for the time being, and it made a recommendation to the prime minister.

The government conducted necessary coordination for inquiry No 12 addressed to the Science and Technology Council, and voted for "general principles of scientific and technological policies" at a Cabinet conference on 28 March 1986.

(2) Contents

a. Basic policy

"Science and technology with an abundance of creativity" should be positioned as the axis for the promotion of science and technology. In this case, full consideration should be given to "development of science and technology maintaining harmony with man and society" and "development of science and technology with importance given to international applications."

b. Promotion of preferential measures

(a) Consolidation and strengthening of promotion structure

Efforts should be made to consolidate a research and development promotion structure, based on the respective roles of industries, academic circles, and government offices. Also, from the viewpoint of vitalizing national experimental and research organizations, basic principles should be laid down concerning their roles from medium- and long-range points of view, based on examinations by the Science and Technology Council.

(b) Consolidation and strengthening of promotion terms

Such measures as "expansion and investments in research and development," "cultivation and securing of experts," "strengthening of foundations for the promotion of science and technology," and "expansion of international exchange and cooperation" should be carried out in comprehensive and flexible ways.

c. Promotion of important fields of research and development

In regard to important fields of research and development, research and development should be carried out energetically and effectively, with priority given to basic, leading science and technology.

The prime minister should formulate basic plans for research and development in various fields which should be promoted on a priority basis.

(a) Promotion of basic and leading science and technology expected to be involved in new developments

(i) Science and technology on substances and materials
(ii) Science and technology on information and electronics
(iii) Life sciences
(iv) Software science and technology
(v) Space science and technology
(vi) Oceanographic science and technology
(vii) Terrestrial science and technology

(b) Promotion of science and technology to vitalize the economy

(i) Development and management of natural resources
(ii) Development and utilization of energy
(iii) Advancement of production techniques and marketing systems
(iv) Reproduction and utilization of resources
(v) Improvement of services to society and livelihood

(c) Promotion of science and technology to improve the quality of society and livelihood

(i) Maintenance and improvement of citizens' mental and physical health
(ii) Formation of individual and cultural lifestyles
(iii) Formation of a comfortable and safe society
(iv) Improvement of the human environment based on a global perspective

2. Basic Plans for Research and Development, Classified by Fields

In line with the Science and Technology Council's recommendation No 11 and the "outline of scientific and technological policies" mentioned in the foregoing paragraph, activities are being carried out to formulate basic plans for research and development in various fields that should be promoted on a priority basis.

(1) Basic Plan for Research and Development Involving Science and Technology of Substances and Materials

Inquiry No 14, entitled "On a Basic Plan for Research and Development Concerning Science and Technology of Substances and Materials," was presented by the prime minister to the Science and Technology Council on 27 May 1986 in order to contribute to the formation of a basic plan for the research and development involving science and technology of substances and materials, as first basic plan for field-classified research and development since the Cabinet decision which outlined science and technology policies.

The Science and Technology Council, which established a Subcommittee for Science and Technology of Substances and Materials (chairman: Yoshimitsu Takeyasu, member of the Science and Technology Council), repeated deliberations and made a recommendation to the prime minister on 28 August 1987.

This recommendation pointed out that importance should be given to the promotion of basic, leading research and development in the science and technology field involving substances and materials in particular, in order to achieve the rapid development of this field which will constitute a basis for the development of society in the 21st century. The recommendation presented important targets for research and development in the following four directions:

Search for new phenomena and theoretical elucidation of various phenomena;
Creation of innovative substances and materials;

Development of materials technologies responding to needs; and
Development of common, basic technologies.

Furthermore, the recommendation pointed out measures to attain these targets.

(2) Measures to Promote Science and Technology To Deal With Aging Society, Mental and Nervous Systems, and Immunity

Under the life science subcommittee's sectional committee for science and technology involving human beings, a study group was formed to conduct studies to lay down a basis for comprehensive promotion measures for science and technology involving human beings, including those dealing with aging society, mental and nervous systems, and immunity, the necessity for which was pointed out in the Science and Technology Council's recommendation No 11, in addition to carrying out the field-classified research and development plan mentioned above. In May 1987, "an opinion concerning basic measures to promote science and technology to deal with aging society" was offered to the prime minister.

In this opinion, proposals were made to conduct systematic rearrangements of important research-development targets and to take measures to promote research activities in light of the fact that hopes are being expressed to promote science and technology to truly vitalize an aged society, which is rapidly approaching, and understand human beings themselves more deeply when developing science and technology in the future.

In regard to the important research-development targets involving science and technology for the aging society, the council, in viewing the next 10 years or so, set research-development targets concerning two research fields: 1) research designed to ensure the health of elderly persons, and 2) comprehensive research to support the livelihood and activities of elderly persons.

Concerning measures to promote research and development, the council pointed out the importance of strengthening the setup for promoting research, including basic research, strengthening the research support system including the supply of laboratory animals, affording sufficient research expenses, fostering and securing young researchers, and promoting international cooperation.

3. Structure for Scientific and Technological Administration

(1) Drafting of plans for basic science and technology policies and comprehensive adjustments

Japanese measures concerning science and technology are basically formulated and carried out by the administrative organs concerned based on their respective jurisdictions. When comprehensive adjustments of these measures are conducted, the prime minister is supposed to consult the Science and Technology Council, which is a subsidiary agency to the Prime Minister's Office.

Also, the Science and Technology Agency carries out such operations as comprehensive adjustments of the business affairs of administrative organs concerned in regard to science and technology, except for those connected with cultural sciences alone and with research at universities.

The Science and Technology Council has been established as the highest deliberative organ for the 1959 science and technology policies, in addition to the abovementioned administrative organs. It was organized by the Cabinet ministers concerned, including the Science and Technology Agency director general, with the prime minister as chairman. It makes recommendations to the prime minister on matters concerning the establishment of basic and comprehensive policies regarding science and technology in general (excluding those connected with cultural sciences alone) and concerning the setting of long-range and comprehensive research targets involving science and technology. Since 1960, when the Council made its first recommendation, "On Comprehensive Basic Measures for the Promotion of Science and Technology, Targeted for 10 Years Hence," it has made the following recommendations for long-range, basic plans covering energy in general: "On Fundamentals of Comprehensive Scientific and Technological Policies in the 1970's" (recommendation No 5, 1971), "On Fundamentals of Comprehensive Scientific and Technological Policies Based on the Long-Range Perspective" (recommendation No 6, 1977), "On Comprehensive Basic Measures for the Promotion of Science and Technology, Designed To Cope With New Changes in the Situation and Based on the Long-Range Perspective" (recommendation No 11, 1984), and "On General Principles for Scientific and Technological Policies" (recommendation No 12, 1985).

Recently it has become more important than ever to develop comprehensive science and technology policies that incorporate national harmony. Therefore, the council, taking into account the Provisional Administration Research Council's basic recommendation (July 1982), is working to strengthen its structure by such means as setting up a policy committee, so as to make contributions to timely, appropriate decisions on principal matters concerning science and technology policies.

In regard to nuclear energy and space development, the Atomic Energy Commission and Space Activities Commission, which are subsidiary agencies of the Prime Minister's Office, formulate their respective long- and short-range plans. In the field of ocean development, too, various plans are formulated for the individual fields, with the Council for Ocean Development, a subsidiary agency to the Prime Minister's Office, submitting reports concerning long-range plans. The Science and Technology Agency effects comprehensive business adjustments, etc., except for matters connected with research at universities, when the administrative organs concerned promote research and development in line with these plans.

(2) Structure for promotion of research and development

Japan's science and technology administrative organizations are shown in Figure 3.1.1.

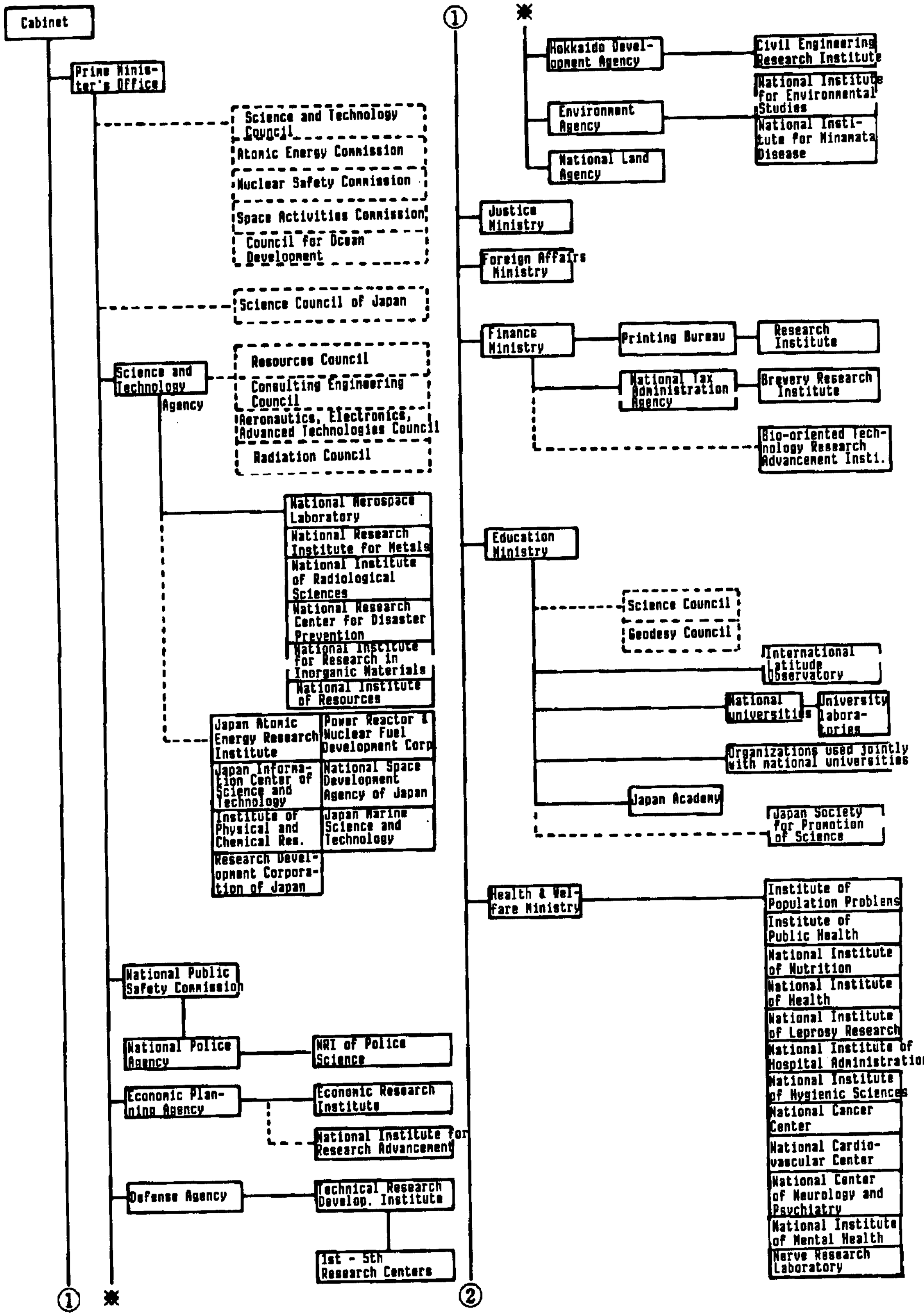
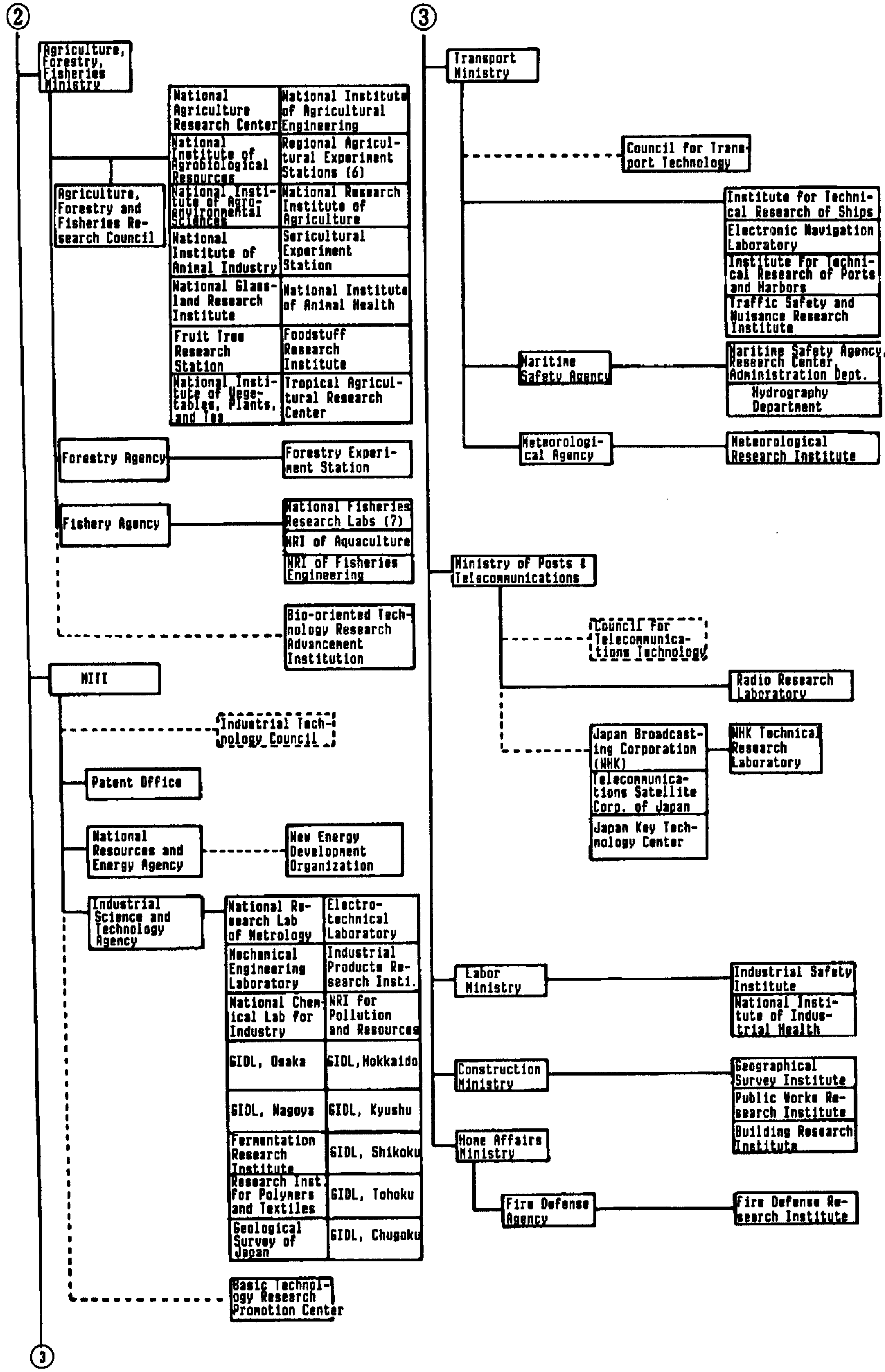


Figure 3.1.1. Organization for Science and Technology Administration in Japan [continued]



[Continuation of Figure 3.1.1]

4. Measures for Promotion of Research Exchange

Recent research and development has become highly advanced and complex, and are extending to boundary and composite areas. Especially at basic stages, the basic fields necessary for research are expanding. To promote creative science and technology in the future, it is important to positively promote the exchange of personnel and materials for research beyond the framework of research organizations and the realization of systems making such exchange possible, and to utilize the limited research resources efficiently and effectively.

In the "recommendation concerning measures to promote administrative reform" made by the Provisional Council for the Promotion of Administrative Reform in July 1985, the following points from the abovementioned viewpoints were suggested as measures to promote research exchange:
1) Promotion of joint research and development beyond the framework of the research organizations of industries, academic circles, and government offices; 2) expansion of opportunities for such activities as mutual announcements of opinions by researchers in different fields and organizations and exchange of information; 3) realization of research systems which are internationally open; and 4) opening of facilities and research information to the public and promotion of mutual uses thereof. Therefore, the recommendation pointed out the necessity for the government to promote the vitalization of research activities at governmental research organizations and to consolidate, improve, and promote the various systems necessary to carry out research exchange smoothly.

During FY 1986, a research exchange promotion law, concerning matters involving legal bottlenecks in promoting research exchange, was enacted in May 1986 in order to eliminate these bottlenecks by taking the abovementioned points into account. In regard to matters to be dealt with through the implementation of various systems, a decision was made at a Cabinet conference in March 1987 "on basic policies concerning the implementation of various systems related to the promotion or research exchange with foreign countries as well as among industries, academic circles, and government offices." Therefore, various measures have been worked out and foundations were consolidated to cope with the increase in social requirements for research exchange (Tables 3.1.2 and 3.1.3).

Table 3.1.2. Contents of the Research Exchange Promotion Law

	Current law	Special measures
1. Appointment of foreigners (Article 3)	Limited to common researchers to be engaged in experiments and research in accordance with reasonable legal principles.	They can be appointed as the manager of a research department or office.
2. Participation in research meetings (Article 4)	As official business (official trip or outside duty) or leave of absence.	In addition, a third measure is to be adopted which would allow participation as an exemption from the obligation to be exclusively engaged in duty.
3. Improvement of disadvantages as to severance pay in cases of temporary transfer to private sectors (Article 5)	In cases of suspension from duty (for research) for the purpose of engaging in research at a school, research laboratory, hospital or other public facility, half the duration of the temporary transfer is to be counted when calculating severance pay.	In cases of suspension from duty in order to carry out research commissioned by the state or joint research with the state, the entire suspension period is to be counted.
4. Improvement in the handling of patent rights, etc., relative to research commissioned by the state (Article 6)	Patent rights, etc., are to be obtained by the state.	Part of patent rights, etc., can be transferred to trustees bearing necessary funds.
5. Gratuitous or low-priced use of patent rights, etc., relative to international joint research (Article 7)	There are many cases in which the use of state patent rights, etc., have been requested free of charge or at low prices when conducting international joint research. Legal grounds are necessary for such use, but there is currently no well-grounded law or ordinance except in specific cases.	A way to achieve this is to be initiated in regard to joint research with a foreign government, foreign organization or international organization.

[continued]

[Continuation of Table 3.1.2]

	Current law	Special measures
6. Waiving of a right to demand damages relative to international joint research (Article 8)	There are many cases in which the state is requested to waive its right to demand damages when carrying out international joint research. Legal grounds are necessary for such a request, but this is impossible because there is no well-grounded law or ordinance at present.	Same as above.
7. Use of state-owned facilities at low prices (Article 9)	To allow the use of state assets at low prices legal grounds are necessary, but currently no well-grounded law or ordinance exists except in specific cases.	A way to achieve this is to be initiated for the case in which one furnishes the results of research which is closely connected to research conducted by a state agency controlling research facilities, and which is particularly useful for the research.
8. Matters for consideration (Article 10)		When conducting international research exchange through the special measures laid down in this law, special consideration should be taken so as to not impair these measures with respect to the obligation to fulfill treaties and other international commitments and to maintain international peace and security.

Table 3.1.3. Basic Policies for Implementation of Various Systems Concerning Promotion of Research Exchange Among Industries, Academic Circles, and Government Offices and With Foreign Countries (Contents of a Cabinet Decision on 31 March 1987)

Items	Contents
1. Promotion of joint research	Consolidation of rules to enable researchers in the private sector, etc., to engage in research activities in national experimental and research organizations in carrying out joint research. Consolidation of rules to approve preferential implementation of state-owned patent rights, etc., which have been obtained as a result of joint research.
2. Promotion of exchange among researchers	Consolidation of the setup to receive researchers in the private sector, etc., with national experimental and research organizations. Simplification of procedures permitting public researchers' research-related sidelines. Checking into short-term appointment of public researchers. Promotion of exchange among researchers by utilizing such systems as that for concurrent services among national research organizations.
3. Exceptions to mapping out public researchers' working hours	Consolidation of rules concerning exceptions to the mapping out of public researchers' working hours.
4. Promotion of research exchange with foreign countries	Promotion of research exchange between national universities and national experimental and research organizations and effective utilization of the thesis and doctoral systems in order to expand the opportunities for academic degrees to be smoothly granted to foreign researchers carrying out research at national experimental and research organizations.
5. Opening to the public of facilities of national research organizations and their information	Furnishing of information concerning the research facilities of national research organizations in order to promote the opening of these facilities to the public. Furnishing of research information by national research organizations and popularization of their research results.

[continued]

[Continuation of Table 3.1.3]

Items	Contents
6. Establishment of research exchange promotion liaison council	Establishment of a research interchange promotion liaison council to achieve close contacts among various ministries and agencies, thereby contributing to the smooth promotion of research exchange.

Chapter 2. Budgetary Appropriations Concerning Science and Technology

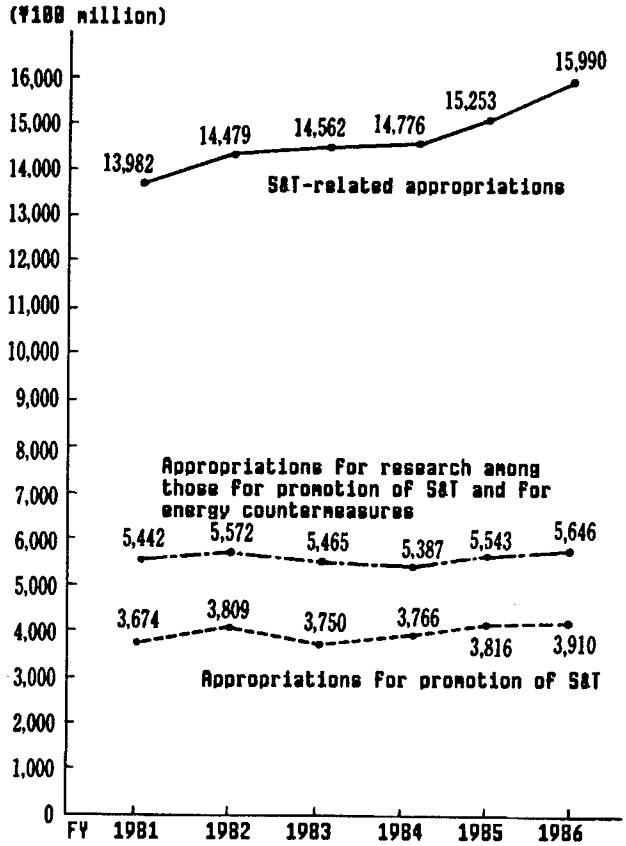
The Japanese budgetary appropriations concerning science and technology (based on tentative calculations by the Science and Technology Agency, hereinafter the same) amounted to ¥1.599 trillion in FY 1986, up 4.8 percent over the 3.2 percent increase during the preceding fiscal year.

Table 3.2.1. Change in Amount of Government Budget for Science and Technology (Unit: ¥100 million)

Items \ Fiscal year		1982	1983	1984	1985	1986
Appropriations for S&T promotion	(A)	3,809	3,750	3,766	3,816	3,910
Rate compared with preceding fiscal year	%	103.7	98.5	100.4	101.3	102.5
Appropriations for research among those for S&T promotion and for energy countermeasures	(B)	5,572	5,465	5,387	5,543	5,646
Rate compared with preceding fiscal year	%	102.4	98.1	98.6	102.9	101.9
Research appropriations other than those among the appropriations for S&T promotion and for energy countermeasures	(C)	8,907	9,097	9,389	9,710	10,343
Rate compared with preceding fiscal year	%	104,3	102.1	103.2	103.4	106.5
S&T related appropriations	(D)=(B)+(C)	14,479	14,562	14,776	15,253	15,990
Rate compared with preceding fiscal year	%	103.6	100.6	101.5	103.2	104.8
State budget in the general account	(E)	496,808	503,796	506,272	524,996	540,886
Rate compared with preceding fiscal year	%	106.2	101.4	100.5	103.7	103.0
(B)/(E)	%	1.12	1.08	1.06	1.06	1.04
State budget in the general account	(F)	326,000	326,195	325,857	325,854	325,842
Rate compared with preceding fiscal year	%	101.8	100.0	99.9	100.0	100.0

Note: 1. The "appropriations for research among those for energy countermeasures" and "research appropriations other than those among the appropriations for S&T promotion and for energy countermeasures" are based on surveys conducted by the Science and Technology Agency.

2. The amounts for each fiscal year are those initially estimated.



Note: The amounts in each fiscal year are those initially estimated.

Figure 3.2.2. Amounts in Each Fiscal Year Are Those Initially Estimated

The state budget in the general account in FY 1986 was up 3 percent from the preceding fiscal year, and the general expenditures, which are expenses calculated by deducting the national bond expenses and local allocation tax grants from the total amount in the general account, constituted a 0 percent increase over the preceding fiscal year. In light of this situation it can be said that the government is paying attention to the repletion of the budget for science and technology (Table 3.2.1).

In the budget for science and technology, the appropriations for research among those for the promotion of science and technology and for energy countermeasures amounted to ¥564.6 billion, up 1.9 percent over the preceding fiscal year, and the ratio of these appropriations to the state budget in the general account was 1.04 percent (Figure 3.2.2). The itemized changes in the science and technology-related budget are shown in Figure 3.2.3. Of these appropriations, the subsidies, commissioning expenses, investments, shares of expenses, etc. (to be termed "subsidies," etc.) in FY 1986 increased to 48.7 percent of the total amount of science and technology-related appropriations in the same fiscal year due to the implementation of large-scale projects in recent years and the increase in the amounts of subsidies and research commissions to special research corporations, the private sector, etc.

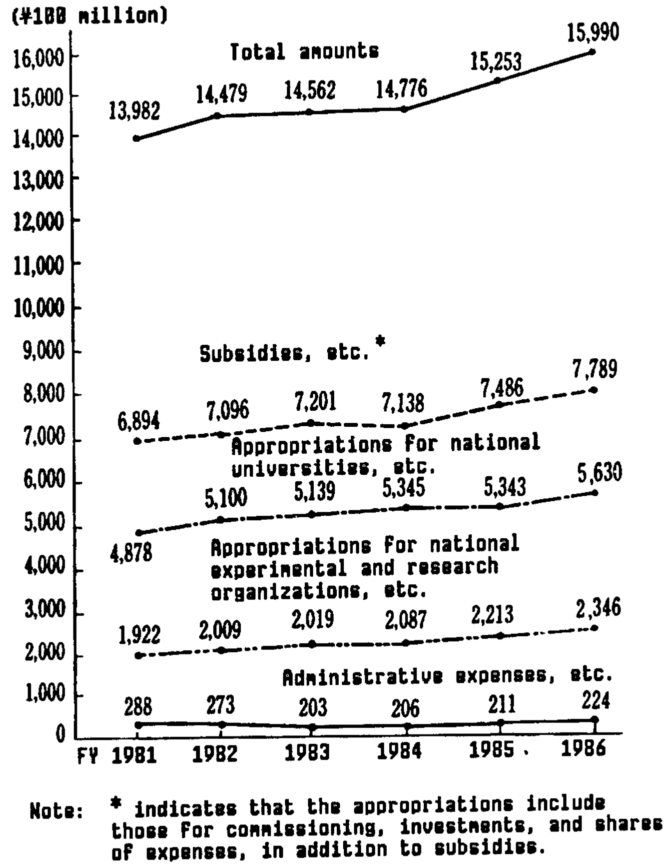


Figure 3.2.3. Change in Amount of Governmental Budget for Science and Technology, by Budgetary Item

The science and technology-related budget classified by ministries and agencies is shown in Table 3.2.4.

Itemized changes in research expenses among appropriations for the promotion of science and technology and for energy countermeasures are given in Figure 3.2.5. This shows that the appropriations for national experimental and research organizations in FY 1986 amounted to ¥162.7 billion, up 3 percent over the preceding fiscal year, while the subsidies, etc., climbed to ¥391.4 billion, up 1.4 percent.

Also, the research appropriations other than those included among the appropriations for the promotion of science and technology and for energy countermeasures amounted to ¥1.0343 trillion, up 6.5 percent over the preceding fiscal year, focusing on those for national universities, etc.

Due to the difference in the financial systems of individual countries, it is impossible to directly compare the amounts of science and technology-related budgetary appropriations and their ratios to the total budget. However, changes in the science and technology-related appropriations in major countries are shown in Table 3.2.6.

Table 3.2.4. S&T-Related Budgetary Appropriations Classified by Ministries and Agencies

(Unit: ¥1 million)

Ministries and agencies	FY 1985				FY 1986			
	A	B	C	B+C	A	B	C	B+C
Diet	517	517	—	517	517	517	—	517
Science Council	—	—	889	889	—	—	863	863
National Police	847	847	—	847	899	899	—	899
Hokkaido Develop. Agency	141	141	—	141	142	142	—	142
Defense Agency	—	—	58,677	58,677	—	—	66,133	66,133
Economic Planning	704	704	—	704	704	704	—	704
S&T Agency	146,986	312,685	100,652	413,337	154,277	321,985	98,357	420,342
Environment Agency	8,524	8,524	—	8,524	8,320	8,320	—	8,320
National Land Agency	298	298	—	298	210	210	—	210
Justice Ministry	787	787	—	787	808	808	—	808
Foreign Affairs "	—	2,633	3,633	6,266	—	2,578	4,017	6,594
Finance Ministry	318	318	578	896	329	329	610	938
Education Ministry	55,888	55,888	657,901	713,789	57,745	57,745	687,845	745,591
Health and Welfare Ministry	26,333	26,333	7,426	33,759	28,015	28,015	8,106	36,121
Agriculture, Forestry, Fisheries "	59,539	59,539	1,727	61,266	60,733	60,733	5,744	66,477
MITI	59,069	63,476	135,196	198,672	56,427	59,832	157,725	217,557
Transport Ministry	11,400	11,400	1,739	13,139	11,511	11,511	1,759	13,271
Posts and Telecommunications "	4,209	4,209	10,049	14,258	4,126	4,126	20,541	24,667
Labor Ministry	585	585	2,242	2,827	599	599	2,371	2,970
Construction "	4,915	4,915	271	5,185	5,065	5,065	751	5,817
Home Affairs "	515	515	—	515	527	527	—	527
Totals	381,575	554,314	970,980	1,525,293	390,954	564,644	1,034,324	1,598,969

Notes:
1. A represents appropriations for the promotion of research and technology.
2. B represents appropriations related to research for the promotion of S&T and for energy countermeasures.
3. C represents research-related appropriations other than "appropriations related to research for the promotion of S&T and for energy countermeasures."
4. Appropriations related to research for energy countermeasures plus C are based on surveys conducted by the Science and Technology Agency.
5. The amounts of each fiscal year are those initially estimated.
6. The figures in the columns and those in the column for totals do not always agree due to having been rounded to the nearest whole number.
7. Among the appropriations C, ¥3.8 billion, for organizations to promote research involving specific industrial technology for living things, is earmarked for the Agriculture, Forestry, Fisheries Ministry, and ¥28 billion for the Japan Key Technology Center is doubly earmarked for MITI and the Ministry of Posts and Telecommunications. (The totals do not involve duplication.)

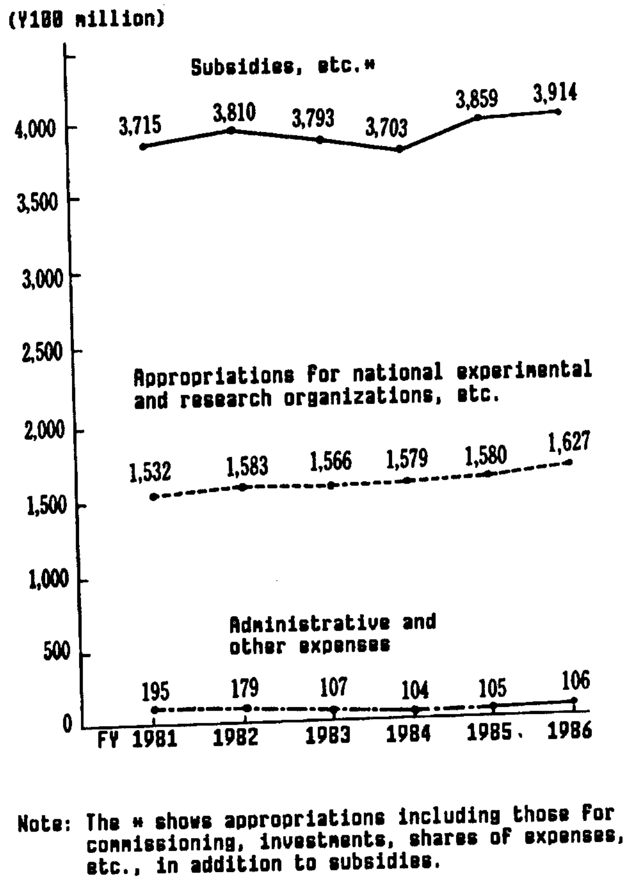


Figure 3.2.5. Change in Total Government Funds for Promoting Science and Technology and R&D Component of Funds for Energy-Related Programs, by Budgetary Item

Chapter 3. Promotion of Research Activities Involving Government Organizations, Etc.

Requests for science and technology in the current economic and social situations are tending to gain strength, and the roles of research activities by government organizations, etc., (including national experimental and research agencies, special corporate research organizations, and universities) are becoming greater than ever.

In this chapter the author will discuss the promotion of research activities by government organizations, etc., by grouping them into national experimental and research agencies, special corporate research organizations, etc., and universities, and also the situations in which cooperative research and development are being promoted in many fields, including development of nuclear energy, research and development of energies other than nuclear energy, development of space, research and development of aeronautical technology, ocean development, life science, and comprehensive research and development.

Table 3.2.6. S&T-Related Budgetary Appropriations in Major Countries

FY	1982	1983	1984	1985	1986
(1) Japan ¥100 million	14,480	14,562	14,776	15,253	15,990
Rate to total budget %	2.9	2.9	2.9	2.9	3.0

Note: The S&T-related appropriations include those for the promotion of science in the general account, research-related appropriations for energy countermeasures, and research appropriations particularly related to universities. For the total budget, appropriations in the general account are employed. Data: "Budget Paper" of Japan.

FY	1982	1983	1984	1985	1986
(2) United States $1 mil	35,762	37,667	42,151	47,028	53,143
¥100 million	89,083	89,459	100,109	112,162	89,546
Rate to total budget %	4.9	4.7	4.9	5.1	5.4

Data: "Federal Government Budget Special Analysis" of the United States

FY	1982	1983	1984	1985	1986
(3) West Germany 1 million marks	11,476	11,314	11,623	12,647	13,228
¥100 million	11,780	10,524	9,701	10,248	10,266
Rate to total budget %	4.7	4.6	4.6	5.0	5.1

Note: For West Germany, S&T-related appropriations are limited to the Federal Government's budget and do not include the greater part of research appropriations for universities, with the entire amount of these borne by the state governments. Data: "Faktenbericht 1986," "Statistics Informationen" and "Finanzberichet" of West Germany.

FY	1982	1983	1984	1985	1986
(4) France 1 million Fr	48,597	56,602	65,511	69,965	74,872
¥100 million	18,418	17,637	17,806	18,576	18,216
Rate to total budget %	6.1	6.4	6.8	7.1	7.3

Data: "Annex to a Budget Bill" of France.

FY	1982	1983	1984	1985	1986
(5) Britain 1 million pounds	3,626	3,923	4,240	4,530	4,652
¥100 million	15,811	14,135	13,458	14,007	11,499
Rate to total budget %	3.2	3.3	3.3	3.4	3.3

Data: Annual Review of Government Funded R&D 1985. The Government Expenditure Plans 1985—86 to 1987—88 Britain

FY	1982	1983	1984	1985	1986
(6) USSR 100 million rubles	115.5	125.4	130.2	134.5	—
¥100 million	39,419	38,689	36,364	41,656	—
Rate to total budget %	3.4	3.5	3.5	—	—

Data: "Soviet National Economic Statistics Yearbook" of the Soviet Union

Note: The accounting classifications of the total budget and S&T-related appropriations vary with nations.

1. Promotion of Research Activities at National Experimental and Research Organizations, Etc.

National experimental and research organizations, belonging to different ministries and agencies, are pursuing their own distinctive research activities. The total expenses (at national experimental and research

organizations, etc.) in FY 1986, including those for experiments and research, personnel and facilities, amounted to ¥234.6 billion, up 6 percent over the preceding fiscal year. These expenses, classified by ministries and agencies, are shown in Table 3.3.1. Of these, the expenses involving applications for the promotion of science and technology are broken down in Figure 3.3.2. The total number of regular personnel at these organizations was 15,237 (including 9,840 researchers), showing a decrease of 111 (including 41 researchers) from the preceding fiscal year.

Table 3.3.1. Appropriations for National Experimental and Research Organizations, Etc.

Unit: ¥1 million)

Ministries and agencies	FY 1985			FY 1986			Remarks
	A	B	Total	A	B	Total	
National Police Agency	847	—	847	899	—	899	NRI of Police Science
Hokkaido Development Agency	141	—	141	142	—	142	Civil Engineering Research Institute
Defense Agency	—	57,819	57,819	—	65,259	65,259	Technical Research and Development Institute
Economic Planning Agency	704	—	704	704	—	704	Economic Research Institute
Science and Technology Agency	24.978	—	24,978	26,899	—	26,899	Appropriations for nuclear energy experiments and research at NAL, etc., and other national organizations (package appropriation)
Environment Agency	7,550	—	7,550	7,318	—	7,318	Appropriations for experiments and research on prevention of environmental pollution, etc., at National Institute for Environmental Studies and other national organizations (package appropriation)
Justice Ministry	787	—	787	808	—	808	Research and Training Institute
Finance Ministry	318	578	896	329	610	938	Brewery Research Institute, etc.
Education Ministry	6,532	—	6,532	6,680	—	6,680	International Latitude Observatory, etc.
Health and Welfare "	9,643	3,033	12,676	9,858	3,646	13,504	National Institute of Health, etc.
Agriculture, Forestry, Fisheries Ministry	54,841	—	54,841	56,013	—	56,013	National Agriculture Research Center, etc.
MITI	34,758	—	34,758	36,066	—	36,066	National Research Laboratory of Meterage, etc.
Transport Ministry	7,264	1,071	8,335	7,313	1,091	8,404	Institute for Technical Research of Ships, etc.
Posts and Telecommunications Ministry	4,209	—	4,209	4,126	—	4,126	Radio Research Laboratory
Labor Ministry	585	602	1,187	599	582	1,181	Industrial Safety Institute, etc.
Construction Ministry	4,305	246	4,551	4,435	686	5,122	Public Works Research Institute, etc.
Home Affairs Ministry	515	—	515	527	—	527	Fire Defense Research Institute
Total (17 ministries and agencies)	157,976	63,349	221,325	162,717	71,874	234,590	

Notes: 1. A shows research-related expenses among the appropriations for the promotion of S&T and for energy countermeasures, and B shows the research-related expenses other than A. All the amounts are included in initial budgetary appropriations. The research-related expenses among the appropriations for energy countermeasures and B are based on surveys conducted by the Science and Technology Agency.
2. The figure totals do not always agree because of rounded numbers.

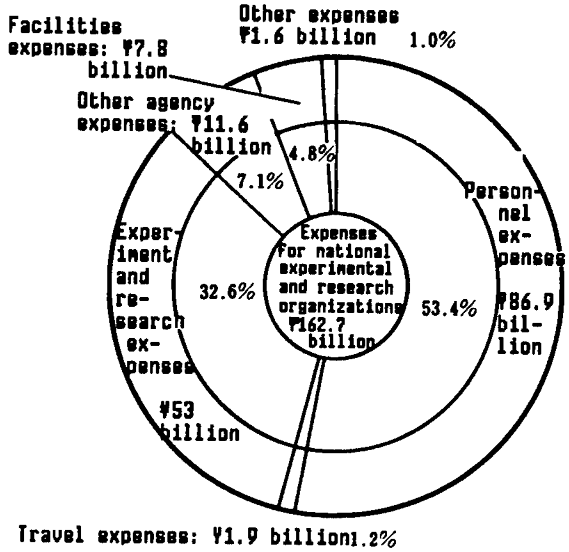


Figure 3.3.2. Breakdown of FY 1986 Budgetary Appropriations for National Experimental and Research Organizations, Etc. (For Promotion of Science and Technology)

(1) What National Experimental and Research Organizations Should Be From Medium- and Long-Range Points of View

To date, national experimental and research organizations have been contributing to the strengthening of the Japanese industrial foundation and qualitative improvement of the people's livelihood, and have also been playing big roles in the promotion and development of science and technology through such activities as studies covering varying fields and subjects in response to administrative needs.

However, because of the considerable changes in the recent social and economic situations, in the international environmental conditions surrounding Japan and in the development of science and technology, the spheres which should be dealt with from scientific and technological angles are expanding more and more and becoming increasingly diverse. National experimental and research organizations are being required to become more active and perform their roles more precisely in response to these changes. In particular, they are required to deal, in a positive way, with strengthening creative research and development which is extremely important for the promotion of Japanese science and technology.

In the "report concerning measures for the promotion of administrative reform" submitted by the Provisional Administrative Reform Promotion Council on 22 July 1985, it was pointed out that, from the standpoint of vitalizing national experimental and research organizations, the Science and Technology Council should conduct research and deliberations on what science and technology should be from medium- and long-range points of view, and that the council should submit its opinion.

In response to this, the Cabinet decision dated 24 September of the same year called for the Science and Technology Council to check into this matter. On 3 December of the same year, the prime minister consulted the Science and Technology Council in his Inquiry No 13 "On What National Experimental and Research Organizations Should Be From Medium- and Long-Range Points of View."

The council repeated deliberations at a meeting of the Sectional Committee on National Experimental and Research Organizations, which had been established under the Comprehensive Planning Subcommittee, and submitted a report to the prime minister on 28 August 1987.

This report noted it as a particularly important policy task for national experimental and research organizations to participate in promoting basic research to create technological seeds for the next generation, and to make international contributions in the science and technology field through internationalization of these organizations.

Also, the report pointed out the following major items for the organizations to engage in to fulfill their roles effectively and efficiently:

Establishing research management suited to basic and leading research, including the creation of seeds;

Reviewing the roles and research systems of national experimental and research organizations precisely and on a timely basis;

Improving research management by such means as urging research agency managers to exercise their discretion;

Preferentially and efficiently promoting the securing of funds and manpower, consolidation of research and other facilities and perfection of research support functions, and flexibly managing conditions that affect the pursuit of research.

(2) Ordinary research

Ordinary research, centered on research in comparatively basic fields, is designed to cultivate the basis of all research activities. Necessary funds for this research are raised chiefly by integrated agency applications for researchers and special appropriations. These two kinds of appropriations totaled ¥34.3 billion in FY 1986, accounting for 53.2 percent of the ¥64.5 billion agency appropriations for national experimental and research organizations (Table 3.3.3).

The integrated agency appropriations per researcher are shown in Table 3.3.4.

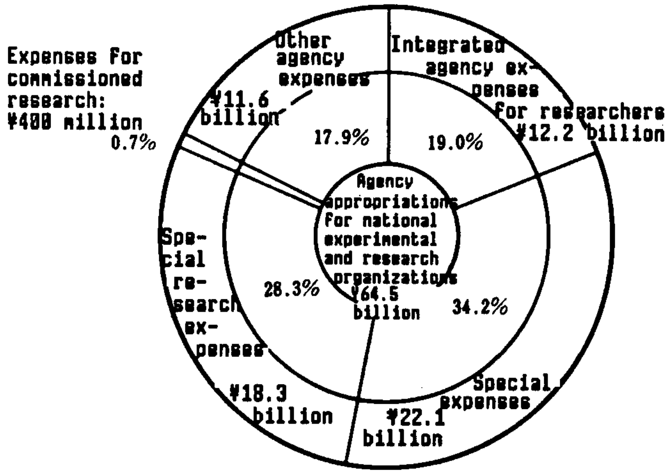


Figure 3.3.3. Breakdown of FY 1986 Budgetary Appropriations for National Experimental and Research Organizations, Etc. (For Promotion of Science and Technology)

Table 3.3.4. Changes in Integrated Agency Expenses Per Researcher, Classified by Fiscal Year

(Unit: ¥10,000)

Classification	FY 1982	1983	1984	1985	1986
Experimental group I	144	144	144	144	144
II	126	126	126	126	126
Nonexperimental group I	91	91	91	91	91
II	82	82	82	82	82

Note: Experimental group I includes research organizations mainly conducting experiments relative to science and engineering and experimental group II--research organizations mainly conducting biological and medical experiments. Nonexperimental group I includes the Economic Research Institute of the Economic Planning Agency, Research and Training Institute of the Justice Ministry, Institute of Population Problems of the Ministry of Health and Welfare, and National Research Institute of Agriculture of the Ministry of Agriculture, Forestry and Fisheries; and nonexperimental group II--the National Institute for Educational Research and National Language Research Institute of the Ministry of Education, and National Institute of Hospital Administration of the Ministry of Health and Welfare.

(3) Special research

In addition to ordinary research, special research needs to be carried out without delay in response to social and administrative requirements. It is to be pursued systematically by limiting its duration and setting

deadlines. The FY 1986 appropriations for special research (including those for the consolidation of facilities, etc., in addition to the agency appropriations) amounted to ¥15.9 billion, down 6.9 percent from the preceding fiscal year.

In FY 1986, 496 subjects were included as topics for special research, which are broken down by ministries and agencies in Table 3.3.5.

Table 3.3.5. Number of Special Research Items and Amount of Budgetary Appropriations, Classified by Ministries and Agencies

(Unit: ¥1 million)

Ministries and agencies / FY	1983 Items	1983 Budget	1984 Items	1984 Budget	1985 Items	1985 Budget	1986 Items	1986 Budget
National Police Agency	2	26	2	26	1	26	2	26
Science and Technology Agency	21	7,614	21	7,228	21	6,712	23	5,876
Environment Agency	12	680	12	628	12	583	12	537
Justice Ministry	1	1	1	1	1	1	1	1
Finance Ministry	1	35	1	35	1	35	2	35
Education Ministry	26	146	23	107	20	85	20	144
Welfare Ministry	9	50	9	50	9	51	9	49
Agriculture, Forestry, and Fisheries Ministry	28	602	28	601	28	600	29	600
MITI	128	2,724	130	2,568	129	2,568	132	2,568
Transport Ministry	19	313	17	372	16	915	15	699
Posts and Telecommunications Ministry	14	1,078	10	1,089	10	889	12	769
Labor Ministry	5	77	5	76	5	74	5	75
Construction Ministry	4	18	4	15	6	32	4	27
Home Affairs Ministry	3	45	3	45	4	45	9	123
Experimental and research expenses for national organizations to achieve such purposes as preventing environmental pollution (package appropriations for the Environment Agency)	117	3,076	117	2,912	114	2,765	111	2,625
Expenses for nuclear energy experiments and research by national organizations (package appropriations for the Science and Technology Agency)	108	1,766	103	1,732	109	1,733	110	1,774
Total	498	18,250	486	17,485	486	17,114	496	15,928

[continued]

[Continuation of Table 3.3.5]

Notes:
1. FY 1986 special research subjects classified by ministries and agencies (including those in the general account for the Ministry of Transport and Labor, and including those at organizations for humane studies in the case of the Ministry of Education) are shown in supplementary data 27.
2. The amounts of budgets include those for the consolidation of facilities in addition to those for experiments and research.
3. All the amounts are those initially estimated for each fiscal year.

2. Promotion of Research Activities at Special Corporate Research Organizations, Etc.

Research activities at special corporate research organizations, etc., are pursued mainly through investments and subsidies from the government and investments from the private sector, etc. These activities are playing big roles in the government research activities, ranking with those carried out by national experimental and research organizations.

Special corporate research organizations, etc., can efficiently pursue meaningful research and development, etc., since they are able to attract talented persons from among government officials, private circles, etc., conduct flexible management and introduce private funds. The roles currently performed by these organizations are significant, since it has become necessary to make overall efforts toward research and development that are becoming large-scale and complex.

Changes in the amounts of government investments and subsidies for special corporate research organizations, etc., established for the purpose of carrying out research and development, are shown in Table 3.3.6.

In addition to these special corporate research organizations designed for research and development, such special corporations as the Japan Broadcasting Corp., Japan Highway Public Corp., and Water Resources Development Public Corp., are pursuing research and development necessary for carrying out their respective business operations, although they are not designated as research organizations.

3. Promotion of University Research Activities

The essential nature of scientific research, which serves as the basis for promoting science and technology, lies in creating new knowledge, rich in creativity, drawing upon the researchers' free concepts and desires for research as sources. Universities make it a fundamental mission to ensure Japan's scientific foundation and improve its scientific level as the core of their scientific research. Their main characteristics include the points that they aim at developing studies ranging over broad fields of culture and social and natural sciences, that respect for the researchers autonomy is essential for the development of learning, and that research and education be promoted in a unified way.

Table 3.3.6. Changes in Amounts of Government Investments and Subsidies for Special Corporate Research Organizations, Etc.

(Unit: ¥1 million)

Item	Fiscal year	1982	1983	1984	1985	1986
Institute of Physical and Chemical Research	Investments	4,049	4,220	4,250	5,636	7,893
	Subsidies	5,183	5,231	5,333	5,460	5,900
Japan Atomic Research Institute	Investments	67,254	67,374	64,287	79,069	79,273
	Subsidies	17,347	17,612	18,302	20,605	22,283
Japan Nuclear-Powered Vessel Research and Development Corporation	Investments	5,763	9,343	6,275	--	--
	Subsidies	1,434	1,475	1,455	--	--
Power Reactor and Nuclear Fuel Development Corporation	Investments	107,041	105,461	107,957	117,178	120,163
	Subsidies	19,440	19,446	19,708	20,604	22,081
National Space Development Agency	Investments	79,025	78,687	76,784	80,941	82,215
	Subsidies	7,351	7,380	7,574	7,920	8,444
Japan Marine Science and Technology Center	Investments	4,328	3,972	3,919	5,541	5,174
	Subsidies	1,030	1,052	1,044	1,159	1,263
Organization to promote research on specific industrial technologies for living things (for business activities by the former Agriculture Mechanization Research Institute)	Investments	80	80	80	75	75
	Subsidies	677	674	689	713	735

Notes: 1. The amounts for the Power Reactor and Nuclear Fuel Development Corp. include those for the special account.

2. All the amounts are those initially estimated for each fiscal year.

3. The Japan Nuclear-Powered Vessel Research and Development Corp. merged with the Japan Atomic Research Institute as of 31 March 1985.

4. In regard to the organization to promote research on specific industrial technologies for living things, there are investments and loans (industrial investment special account) for investment and financing business activities, etc., in addition to those mentioned in the table.

The expenses for supporting the scientific research activities at research facilities of Japan national, public, and private universities, attached research institutes, organizations used jointly with national universities, etc., are difficult to grasp correctly because the educational and research activities at universities are developed in inseparable and unified ways. However, they can be grouped into ordinary, standard research expenses, those specifically integrated according to the research contents and necessity, those intended for business activities, and other research expenses. Also, expenses to consolidate research facilities carry heavy weight.

Of these, ordinary research expenditures are defrayed to form the foundations of the researchers' free research. At national universities, integrated university expenses per teaching staff member, expenses for the staff member's trips for research purposes, etc., are integrated in addition to the personnel expenses for the teaching staff. For private universities, aid, including personnel expenses, is given for their educational and research activities as a whole through ordinary expenditures.

There are varying expenditures among special research expenses, too. They include scientific research subsidies in terms of expenses for research aid, designed to achieve an exceptional development of superior scientific research and to make contributions to the promotion of Japanese sciences. The scientific research subsidies are to the granted in anticipation of high-degree research results, by granting subsidies for particularly important research that conforms to the scientific trends of Japan among studies voluntarily planned by individual researchers or groups at universities, etc. These subsidies have been playing extremely important roles in promoting front-line scientific research in Japan by such means as fostering superior research groups as well as creating much creative, innovative knowledge. In FY 1986, they were used to perfect "general research C" to promote creative, advanced basic research, "encouragement research A" to encourage young researchers to carry out superior research, "experimental research" to promote research for experimental and application purposes, "expenditures to promote the opening of research results to the public" to assist in the popularization of research results and making them accessible to the public, and "surveys on overseas sciences" to promote overseas scientific research (Table 3.3.7).

Also, fostering superior young researchers, rich in creativity, is the most important task for strengthening and developing the foundations for scientific research.

From these points of view, the Ministry of Education granted research bonuses for a period of 2 years to those who had finished doctoral courses at graduate schools (PD) and those enrolled in such courses (DC) (¥209,000 monthly for PD and ¥121,000 for DC), and also granted money to defray their research expenses (scientific research subsidies: under ¥1.2 million). Therefore, the ministry established a perfect, full-scale fellowship system ("special researcher system" created in FY 1985 as a project of the Japan

Table 3.3.7. Items of Research Using FY 1986 Scientific Research Subsidies, and Amounts of Budgetary Appropriations

(Unit: ¥1 million)

Research items, etc.	Purposes and contents of research items	Amount of appropriations
Scientific research	Aid in research expenses.	42,180
Research to be specifically promoted	Preferential promotion of research evoking high international evaluation and exhibiting possibilities of bringing about exceptionally good results.	2,300
Special research	Research to be carried out for a long time involving spheres in which scientific and social requirements are extremely strong. It is being pursued in regard to cancer, natural disasters, environmental science, and energy.	5,650
Specific research	Research to be conducted for a definite period (3 years) involving spheres in which scientific and social requirements are strong. It is being pursued in regard to life sciences, materials sciences, etc.	5,270
Comprehensive research	Research to be conducted jointly by researchers of different research organizations, surpassing the limits of individual research organizations [grouped into concretely focused research (A) and planned research including research plans (B)].	2,710
General research	Research to be conducted jointly or individually by researchers at the same research organization (grouped into A, B, and C according to monetary amounts). (A) ¥10 million to less than ¥50 million (B) ¥3 million to less than ¥10 million (C) Less than ¥3 million	14,890
Experimental research	Experimental and application-oriented research the results of which might be put to practical use through further development of research, based on accumulated research results.	3,615
Encouraged research (A)	Research to be conducted by individual young researchers belonging to research organizations and having short research careers (research expenses: less than ¥1.2 million)	4,230

[continued]

[Continuation of Table 3.3.7]

Research items, etc.	Purposes and contents of research items	Amount of appropriations
Encouraged research (B)	Research to be individually carried out by teachers at kindergartens, elementary schools, or junior or senior high schools (research expenses: less than ¥300,000)	90
Overseas scientific research	Field research, international joint research, and other necessary surveys and research overseas.	1,525
Promotion of special research	Aid in urgent and important research tasks.	1,900
Promotion of opening of research results to the public	Aid in releasing to the public research results and scientific data having high scientific value.	980
Specific encouragement	Promotion of characteristic research projects carried out by private scientific research organizations on the basis of strong scientific and social requirements.	340
	Total	43,500

Society for the Promotion of Science) to enable researchers to devote themselves to autonomous research activities with unrestricted conceptions.

In FY 1986 there were about 1,600 applicants for the system, while 244 persons were accepted.

In light of the fact that various requests concerning scientific research at universities have been made recently by different quarters of society, including industrial circles, the Ministry of Education has also been carrying out measures designed to help universities respond to social requests and lend their cooperation in appropriate and positive ways by making the most of their characteristics from their autonomous positions bearing their intrinsic missions in mind. In FY 1983, it inaugurated a system for "joint research with the private sector, etc." designed to receive researchers to national and other universities from the private sector, etc., and have these researchers conduct joint research involving common subjects. Researchers within and outside the limits of universities are taking great interest in this system. Therefore, joint research was carried out on 160 subjects in FY 1984, 216 in FY 1985, and 272 in FY 1986, focusing on such fields as the development of materials, development of

machinery and equipment, and biotechnology. In addition, the Ministry of Education is promoting commissioned research at national universities, etc., the receiving of commissioned researchers, joint research with researchers in the private sector and other circles by using scientific research subsidies (for experiments and research), and perfection of industry-university joint projects through the comprehensive research liaison council, etc., promoted by the Japan Society of the Promotion of Science.

Furthermore, international exchange and cooperation are a requirement essential to scientific research and, for the expansion of this research, it is important to improve the scientific level of Japan through international exchange and also to make contributions to the formation of mankind's intellectual assets through international scientific exchange and cooperation. Therefore, inviting researchers from foreign countries, the overseas dispatch of Japanese researchers, joint research with foreign countries, etc., have been promoted so far as means of international scientific exchange focused on universities. Cooperative projects between nations through agreements and multilateral exchange as well as cooperation through international organizations have also been carried out in a positive way.

4. Comprehensive Promotion and Coordination of Important Research Business Activities (Science and Technology Coordination Expenses)

With science and technology becoming frenzied and complex in recent years, it has become extremely important to promote and coordinate research and development from comprehensive points of view by such means as strengthening organic cooperation among industries, academic circles, and government offices and pursuing consistent research and development. Therefore, requirements have become strong, especially for the Science and Technology Council, to strengthen comprehensive coordination functions. In light of this situation, a system for science and technology promotion and coordination expenses was established in FY 1981 to comprehensively promote and coordinate important research business activities necessary for the promotion of science and technology, in accordance with the policies of the Science and Technology Council, by abolishing the special research promotion and coordination expense system previously adopted.

In regard to the coordination expenses, the Science and Technology Council decided on a "basic policy for the utilization of expenditures for the promotion and coordination of science and technology" on 9 March 1981 (revised on 27 November 1984) to implement these expenses, based on the following points, in order to promote research and development, in answer to strong national and social needs, from a long-range perspective;
1) promotion of advanced, basic research; 2) promotion of research and development requiring the cooperation of multiple organizations;
3) strengthening of organic industry-academic-government cooperation;
4) promotion of international joint research; 5) flexible responses in cases of need for urgent research; and 6) implementation of research evaluation, and investigation and analysis of research and development.

On 10 April 1986, the council decided to especially promote science and technology involving substances and materials and the field of life sciences on a priority basis in accordance with a decision made by the council's policy committee "on concrete implementation of FY 1986 expenses for the promotion and coordination of science and technology." It then carried out seven research tasks and five investigative tasks in addition to those continued from the preceding fiscal year. It also conducted such tasks as emergency research on AIDS (acquired immune deficiency syndrome), which has also become a social problem in Japan, in an effort to make mobile and flexible international responses to the occurrence of emergencies during the fiscal year.

Furthermore, it decided to work for preferential basic research at national experimental and research organizations beginning in FY 1985 in light of the importance of the roles to be played by Japan in the field of basic research.

An outline of the research tasks carried out, including the coordination expenses and the amounts of budgetary appropriations, are shown in Table 3.3.8.

Table 3.3.8. Tasks To Be Carried Out With FY 1986 Expenses for Promotion and Coordination of Science and Technology (Outline)
(Unit: ¥1 million)

Tasks	Outline	FY 86 budget
I. Promotion of basic, leading S&T fields		
1. Fields to be promoted as priorities		
(1) S&T on substances and materials (a) Research on development of superconducting and very low temperature basic technologies	To contribute to the establishment of superconducting and very low temperature basic technologies indispensable for the practical use of innovative technologies represented by nuclear fusion, linear motor cars, etc., research is to be conducted on (1) the development of techniques to lengthen the size of high-performance superconducting materials and turn them into coils; (2) acquisition and analysis of data on the properties of very low temperature materials; and (3) the upgrading of very low temperature freezing and cooling systems.	214

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
(b) Research on development of techniques to evaluate the reliability of structural materials	To establish techniques to evaluate the reliability of estimates of the life and remaining life of structural metal materials used for industrial plants and public structures, such as bridges, research is to be conducted on (1) establishing techniques to use databases to estimate life and remaining life; (2) establishing techniques to evaluate high-temperature damage (demonstration tests in high-temperature environments); (3) establishing techniques to evaluate environmental strength (demonstration tests in corrosive environments); and (4) establishing monitoring techniques (using AE, supersonic waves, etc.).	174
(c) Research on basic techniques to create new materials by the hybridized structure designing technique	Creating high-performance multifunctional new materials with organic or inorganic metals which are theoretically combined and controlled (hybridized) on atomic and molecular levels, and developing design theories for the structure of materials, databases, control techniques, analysis and evaluation techniques, etc., are to be carried out comprehensively.	174
(d) Research on techniques for high-output wavelength variable lasers and laser processing	To develop laser processing techniques, possibilities for which are newly expanding, research is to be conducted on the development of (1) laser characterized by high output and wavelength variables; and (2) techniques for the synthesis and processing of materials using the wavelength selectivity of the high-output wavelength variable laser.	282
(e) Research on development of techniques to generate, measure, and use superhigh temperatures	To establish a technique for the use of superhigh temperatures, which is expected to offer strong possibilities as an important technique used to create new materials, research is to be conducted on (1) developing a technique to control the stable generation of superhigh temperatures by high-frequency thermal plasma; (2) developing a technique to measure a superhigh	359

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
	temperature state by using lasers, etc.; and (3) developing and evaluating new materials using superhigh temperatures.	
(f) Research on techniques to analyze and evaluate materials with high performance and functions through the use of new beam techniques	(1) Analysis and evaluation techniques using X-rays obtained from synchrotron orbit radiation (SOR); (2) analysis and evaluation techniques using very strong low-speed positron beams; and (3) analysis and evaluation techniques using submillimeter waves, are to be developed to contribute to the establishment of analysis and evaluation techniques using higher degree new beam techniques, necessary for the development of new materials offering high performance and functions, such as electronic and optical materials and functional chemical materials.	452
(1) Life sciences		
(a) Research on the development of laboratory animals, etc.	(1) Research on development of new diseased animal models through embryological technology; (2) research on the characteristics and utility of small primates, etc., which are used as laboratory animals during the initial stage; (3) research on the establishment of techniques to examine the qualities of laboratory animals; (4) research on the development of techniques to preserve biological materials, such as fertilized eggs, embryos and tissues; and (5) development of a strain establishment cultured cell experiment system, indispensable for studying cell functions, is to be conducted to contribute to the supply of high-quality laboratory animals, cultured cells, etc., indispensable for the promotion of research in the life science field.	93
(b) Research on the development of techniques to analyze and use biomembranes	Techniques to analyze, on the cellular level, the high sensitivity, high identification and separation functions, etc., of biomembranes and to use them as separated and concentrated films of substances, biosensors, etc., are to be developed for the enhancement and	244

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
	application of techniques to use biomembranes with such functions as selectively taking specific substances into cells and quickly identifying very small amounts of substances, such as hormones.	
(c) Research on the development of techniques to analyze, modify, and imitate functional proteins	Developments of (1) techniques to analyze the structures and functions of functional proteins (analyses and estimates of three-dimensional structures), (2) techniques to design functions and grant new functions), and (3) techniques to imitate protein functions (artificial enzymes, etc.), are to be carried out to establish effective techniques to use the functions of functional proteins, which have functions inherent to living things and are expected to be widely applied to medical, industrial, and other fields, thereby achieving the development of new spheres of life science.	144
(d) Research on techniques to probe and use physiological activators produced by new symbiotic microorganisms	Developments of (1) methods to probe, separate, and cultivate symbiotic microorganisms, (2) methods for the reference and dissociation of physiological activators produced by symbiotic microorganisms, and (3) techniques to use these substances, are to be conducted to use the physiological activators produced by microorganisms coexisting with insects, plants, etc., and whose existence has been recently confirmed as medicine and agricultural chemicals.	55
(e) Research on the development of a common basic technology supporting cancer research	In accordance with the basic policies exhibited by the Council for Science and Technology and the Cabinet Council on Cancer Countermeasures, a common basic technology indispensable for the promotion of cancer research is to be established by carrying out the development of (1) a technique related to genes and proteins to conduct molecular-level analyses of the course followed when normal cells become cancerous, and (2) a technique for the automatic production of monoclonal antibodies and high-frequency CT technology for the development	463

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
	of a technique to contribute to diagnosis and treatment, with attention paid to the specific nature of cancerous cells.	
(f) Research on the development of a technique to analyze and use chromosomes	To establish a technology to operate appropriately chromosomal functions incorporating high-order life phenomena in such eukaryotes as higher animals and plants, thereby developing a new technological sphere in the field of life science, research is to be carried out involving the development of techniques (1) for the separate refining of chromosomes, (2) for the analysis of the structures and functions of chromosomes, (3) for the introduction of genes into chromosomes, and (4) for the introduction of chromosomes into cells and for its efficient disclosure.	240
(g) Research on the development of basic technology to explain cerebral functions	To contribute to the quick promotion of research on cerebral functions and related items, expected to make progress in a wide range of S&T fields including information and electronic S&T as well as life sciences, basic research is to be conducted mainly on the development of a new technology to analyze cerebral functions using such equipment as positron-CT and NMR and molecular biological methods, with consideration given to the importance of explaining the information processing functions of brains in connection with physiology, information processing technology, etc.	250
(h) Research on a basic technology to use bioenergy conversion functions	Developments of (1) a high-efficiency optical information processing technique using the sense of sight as a model, (2) techniques for high-efficiency production and use of ATP (adenosine triple phosphoric acid), and (3) bioenergy conversion devices (including modeling of actuator mechanisms of living bodies) are to be carried out to further expand the scope of application of energy conversion functions in living bodies, offering such characteristics as high efficiency and ultra-small size.	279

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
(3) Common fields (a) Research on the creation of new materials using gravity-free environments, etc.	To establish basic techniques to create materials with new properties and functions, including semiconductors, composite materials and biomaterials, by using gravity-free environments, experimental equipment working properly even in a gravity-free environment is to be developed and aboveground tests are to be conducted involving themes that will make it possible to expect tests to be conducted early in gravity-free environments.	296
2. (a) Research on advanced use of chemical compound information, etc., by joint use of networks	To promote the circulation of scientific and technological information about chemical compounds, etc., and to achieve advanced use of such information, application software necessary to form online network systems related to S&T information about compounds, etc., is to be developed and research is to be carried out concerning the formation of integrated compound database systems comprehensively using compound data located at experimental and research organizations, etc., of various ministries and agencies.	365
(b) Research on the effective use of marine spaces, etc., by marine structures	To contribute to the development of marine structures for use in offshore sea areas 50-100 meters deep around Japan, the development of techniques to grasp natural environments, necessary for the design and construction of marine structures, basic techniques to construct large, floating marine structures, and wave-controlling techniques to protect marine structures from severe waves, is to be conducted as basic techniques common to different kinds of structures, and development is also to be conducted to improve the durability of marine structures by such means as preventing corrosion.	169

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
(c) Research on the development of a new research system in the 200-mile waters around Japan	To strengthen and perfect maritime research, multifarious in terms of time, space and subjects, involving the 200-mile stretch of water, research is to be carried out for the development of (1) advanced observation machinery and equipment including sensors, which are highly reliable and make it possible to observe maritime situations efficiently, (2) systems to obtain various maritime data by using ships, buoys, etc., and (3) new seabed research techniques enabling precise research on seabed topography and strata, to be conducted, and (4) improved reliability of data obtained by marine observation machinery and equipment.	212
(d) Research on database system to support chemical substance designs, etc.	To establish common models to support designs for various substances based on information processing techniques now in practical use, leading to the construction of database systems to support designs, etc., for new chemical substances, developments are to be carried out of (1) techniques to construct database systems, (2) structural design database systems for proposed designs, and (3) reactional design database systems for proposed structural substances.	169
(e) Research on the development of techniques to use deep marine resources effectively	To establish techniques for the effective use of hitherto-overlooked deep marine resources in order to achieve high-degree utilization of sea areas and further promote biotechnology, research is to be conducted concerning (1) techniques for the effective use of deep water based on location terms (deep water utilization equipment to be installed on the sea and on the ground), (2) techniques for underwater afforestation (creation of seaweed areas using artificial light), and (3) techniques to probe and cultivate deep-sea microorganisms.	210

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
II. Promotion of R&D of strong national and social needs		
(a) Research on the development of techniques to cope with snow damage in areas of high snowfall	To solve the problem of snow damage in areas of high snowfall, research is to be conducted on overall analyses, tests in practical application, evaluation, etc., in regard to techniques for (1) preventing snow damage in urban areas, focused on the utilization of the outflow of underground water through cracks, (2) predicting local, short-time snowfall and using information about snow and ice, (3) predicting snow-slides in the vicinity of villages between mountains.	36
(b) Research on the development of science and technology to deal with an aged society	To deal with a rapidly arriving aged society from scientific and technological aspects, research is to be conducted on the development of (1) techniques to probe aging factors (factors influencing Alzheimer's dementia, etc.) and (2) methods of health care for aged persons (including techniques to measure the degree of aging, remote medical treatment systems, and bedsore prevention systems).	305
(c) Research on earthquake tectonics in areas of active crust activities in central Japan.	To clarify the earthquake tectonics in central Japan and the surrounding sea areas and contribute to further promotion of research on earthquake prediction in these areas, research is to be conducted on earthquake tectonics along (1) the east edge of the Sea of Japan and the vicinity of Fossa Magna, (2) the vicinity of the plate intersection in the land area, and (3) the vicinity of the triple plate intersection in the sea area, in addition to comprehensive research on (4) earthquake tectonics.	175
(d) Research on the development of systems to estimate the degree of landslide danger	Development of (1) methods for the adoption of systems to estimate the extent of landslide danger (involving four factors--topography, geology, vegetation, and the ground), and (2) methods of estimating the	86

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY86 budget
	degree of landslide danger are to be carried out to estimate areas which are likely to suffer from landslides due to heavy rainfall and to develop systems to estimate the degree of these disasters and provide guidelines for such emergency activities as warning and refuge.	
III. Positive promotion of international joint research		
(a) Research concerning the evaluation of toxicity of combustion gas during fires with the cooperation of the United States and Canada, and on ensuring greater safety of construction materials, etc.	To achieve international unification of methods for evaluating the toxicity of combustion gas during building fires and contribute to ensuring greater safety of construction materials, etc., research is to be carried out on the following items with the cooperation of the United States and Canada: (1) Improvement and practical use of combustion test equipment enabling the conditions found in actual fires to be reproduced, and unified methods of evaluating the toxicity of combustion gas by using this equipment; and (2) tests conducted during substantial fires to confirm the universality of the test equipment and toxicity evaluation methods.	39
(b) Research on the probing and utilization of new useful gene resources with the cooperation of ASEAN nations	To probe new useful gene resources among microorganisms and plants in the tropical area through joint research with ASEAN nations and to establish techniques to use them for new medicine, agricultural chemicals, food resources, etc., research is to be conducted on (1) the probing and utilization of tropical microorganisms as new useful gene resources; (2) probing and utilization of tropical plants as new useful gene resources; and (3) systems to develop and utilize useful gene resources.	69
(c) International joint research on techniques to test and evaluate new materials	As it is necessary to establish materials testing and evaluation techniques, common among other nations, for conducting research and development of new materials, joint research is to be conducted with	171

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
	countries in Europe and America concerning (1) techniques to test and evaluate new important materials (engineering ceramics, superconducting materials, etc.), and (2) testing and evaluation techniques with common bases (surface chemical analysis, abrasion tests, etc.).	
(d) Joint research with ASEAN nations concerning improvement and application of remote sensing techniques	To contribute to the promotion of the effective use of earth observation satellites and plans for the rational use of land in the ASEAN area through joint research with ASEAN nations, research is to be conducted on (1) the upgrading of remote sensing technique (application of Japanese remote sensing techniques to ASEAN nations), and (2) explanation of environmental characteristics, etc., of tropical area (methods for grasping environment characteristics of forestry and agriculture, etc.).	130
IV. Promotion of research and analyses		
(a) Research on the direction of the development of advanced science and technology and prospects for scholastic research fields	Basic data necessary for comprehensive direction of advanced science and technology promotion in the future are to be obtained by exploring (1) the trends of technological developments during the next 30 years in Japan's important technological fields (technology forecasts); (2) the direction of basic research aimed at innovative technologies (with an eye on geophysical research and development); and (3) the direction of future research and development in the scholastic research field concerning substances and materials.	59
(b) Research on the trends of experts, investments, and circulation of information in order to contribute to the smooth promotion of research	Basic data are to be obtained in studying measures to replete and bolster experts in supporting R&D activities, investments, and circulation of information by investigating and analyzing (1) the quantitative and qualitative substance of capable researchers and their demand-supply trends; and (2) the actual situations of statistics	24

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
and development activities.	on R&D activities in countries in Europe and America, differences between them and and Japan in this connection, etc.	
(c) Investigation and research to clarify the problematical points in achieving harmony between S&T focused on life sciences and man and society	In light of the fact that the rapid development of life sciences, etc., is arousing various arguments from the viewpoint of harmonizing science and technology with man and society, problematical points in achieving this harmony are to be gathered and analyzed from the standpoint of smoothly promoting the research and development of life sciences.	13
(d) Surveys on the trends of strengthening the roles and functions of national experimental and research organizations	Basic data necessary for determining what the Japanese national experimental and research organizations should be from medium- and long-range points of view are to be obtained by widely grasping various circles' opinions on such matters as the problematical points involving national experimental and research organizations' research activities, etc., and the trend of strengthening the roles and functions expected of these organizations, and by carrying out surveys on the situations of activities by national experimental and research organizations abroad, etc.	26
(e) Analyses of the present situation, trends, potentials, etc., of research and development through the development of methods for the comprehensive processing of information about research and development	Basic data necessary to evaluate the planning, drafting, trends, etc., of scientific and technological policies are to be obtained by grasping and analyzing the present situation, trends, potentials, etc., of research and development through the development of programs and databases designed to extract necessary data from different kinds of information about research and development and to summarize and analyze them.	44
(f) Surveys on basic techniques for creating new functions by such	To clarify the evolutional direction of future research and development aimed at applying rare metals to new functional materials, surveys are to be carried out	14

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
means as purifying rare metals to a high degree	on (1) superhigh purification of rare metals; (2) analyses of superfine impurities in superhigh-purity rare metals; and (3) studies on various technical problems concerning the occurrence of new functions in superhigh-purity rare metals and their compounds.	
(g) Surveys on basic techniques to reveal new functions and ease of thermal stress through the use of functionally gradient materials	To clarify the evolutional direction of a technique for functionally gradient materials (for continuous control of microscopic compositions and structures of various parts of materials), surveys are to be conducted on problems concerning the following items which are among the most important tasks in such fields of advanced technology as aeronautics, space, and the development of nuclear fusion reactors: (1) needs for functionally gradient materials and material designing techniques based on these needs; (2) techniques to control the structures of functionally gradient materials, and (3) techniques to evaluate the properties of functionally gradient materials.	13
(h) Surveys on the development of intellectual man-machine communication systems	To obtain future prospects for research and development concerning intellectual man-machine communications systems covering wide technological spheres, because the facility of dialogues between man and systems is expected to become essential with the upgrading of systems, surveys are to be conducted concerning (1) application systems, (2) R&D for the realization of intellectual functions, and (3) analyses and studies of various characteristics of man.	12
V. Urgent research and flexible international responses		
(a) Surveys and studies on the possibility of a concept involving	To check into the possibility of international basic research program focused on the essential elucidation of high-order functions of living bodies, such	20

[continued]

[Continuation of Table 3.3.8]

Tasks	Outline	FY 86 budget
international basic research programs	as brains and metabolism, as part of Japan's positive efforts toward international contributions in the fields of basic research, surveys are to be conducted on the present situation of research relative to this concept and the actual situation of research implementation systems, etc., and studies based on survey results are to be conducted involving what research fields are desirable for materializing the concept.	
(b) Surveys concerning the explanation of the formation process, etc., of the lift system in the Pacific	In light of the fact that great interest is being taken by people in various fields, including geophysical science and biology, in the lift system consisting of sea-bottom outlets of high-temperature substances gushing out from within the earth, surveys are to be carried out on concrete contents of research, sea areas as a subject for research, etc., which will become necessary in carrying out international joint research with France and South Pacific nations.	8
(c) Urgent research on the development of an AIDS virus assay	As it is feared that there will be an increasing number of AIDS patients in Japan, research must be conducted on developing a virus assay that will become the basis for grasping progress in the course of the disease and determining the effect of medicine.	53
(d) Urgent research on the elucidation of the course of occurrence of El Nino	In regard to El Nino, which brings about climatic changes on a global scale, a phenomenon foreboding it has been recognized this year, too. Therefore, research must be carried out by such means as conducting detailed observations and analyses of this phenomenon from its occurrence to its full development, which are essential for explaining the mechanism of this occurrence.	60

5. Promotion of Creative Research and Development

Creative research and development focused on research at national experimental and research organizations has been pursued in the past, but the following new measures have been carried out since FY 1981:

(1) International Frontier Research System

(i) Circumstances leading to the system

Science and technology, now showing remarkable progress, is contributing to the progress of the social economy. However, the appearance of new, important knowledge supporting such science and technology has been stagnating recently, and its process is becoming deadlocked. To maintain future science and technology development, it is essential to extract scientific knowledge as a source for innovative technology and return it closer to its foundations.

Japan has already been using the results of basic research conducted in Europe and America and has been able to expand its social economy based on these results. With the improvement of its international position, however, it is now obligated to fulfill its leading role in extracting new scientific knowledge and make contributions to the world, breaking from its catch-up-and-pass type of action.

Therefore, in October 1986, the Science and Technology Agency inaugurated an international frontier research system at the Institute of Physical and Chemical Research with a view to positively extracting such new knowledge as will become the root of technological innovation in the 21st century, by inviting researchers from many fields beyond the scope of the conventional research system and creating a structure that is internationally open.

(ii) Outline of the system

(a) Outline of the organization

The international frontier research system is an internal organization of the Institute of Physical and Chemical Research, but it takes a different managerial form with research conducted within a structure consisting of two research fields and seven research teams under the system manager (Figure 3.3.9).

(b) Characteristics

The international frontier research system is being conducted with the following characteristics, involving a structure that is fluid and internationally open.

i) Research structure with the regimentation of research abilities in many fields.

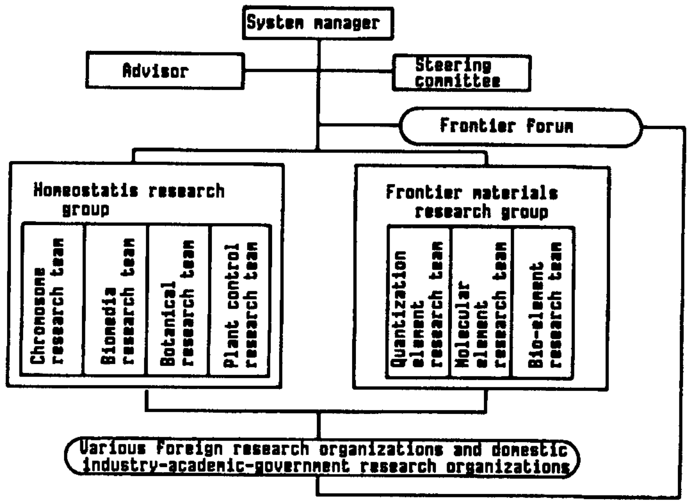


Figure 3.3.9. Organization of International Frontier Research System

ii) Research structure that is internationally open.

iii) Long-term research with a fluid lineup of researchers.

iv) Positive utilization of young researchers.

v) Cultivation of new knowledge substantiated by experiments.

vi) Establishment of arenas enabling creative concepts to be formed in a free, magnanimous atmosphere, with foreign researchers also appointed as leaders of teams involved in researching chromosomes, molecular elements, and biological elements.

(c) Research fields

Research by the international frontier research system is now being conducted in the following two fields to extract scientific knowledge, with a budgetary appropriation of ¥1.119 billion for FY 1986:

i) Research on homeostasis of animals and plants, focused on aging processes

This research is designed to explain the functional mechanism (homeostasis) by which animals and plants maintain their total balance so that they can adjust their own physiological functions and not deviate from their normal conditions at any time, with the hope of using this mechanism in a wide range of fields, including aging controls to cope with an aged society in the 21st century and the creation of plants capable of responding to such diverse environments as dryness.

ii) Research on materials with new functions (frontier materials)

This is aimed at explaining the superfine conditions of cells, biomolecules including proteins, high polymers, metals, etc., and various phenomena arising from combinations of these substances, with the expectation of creating frontier materials (new functional elements, etc.) which will constitute the bases of information science, etc., of the new age.

(2) System for the Promotion of Creative Science and Technology

(i) Circumstances leading to the system

It is important for Japan, which aims at establishing a place for itself on the basis of science and technology, to free itself from its conventional position of depending upon introduced technology and to make its own efforts to probe the science and technology seeds that will become a source of innovative technology.

From this point of view, the Science and Technology Agency established a system for the promotion of creative science and technology in FY 1981 and decided to utilize, as the parent body to promote this system, the Research Development Corporation of Japan, which had the function of actual history of organizing industrialization development projects by connecting researchers at universities, national experimental and research organizations, etc., and industrial circles through such business activities as the commissioned development of new techniques and services for development.

The characteristic of the system during this fiscal year lies in adopting a plan strictly focused on "man" (fluid research system), with the perception that individuals' superior abilities and flexible research management are essential for creative research activities.

In the 6 years since the system's inauguration, research has been progressing smoothly and many noticeable seeds have already been created.

(ii) Outline of the system

(a) This system is designed to efficiently create seeds for Japanese innovative technologies by adopting a new "man"-centered system (fluid research system) to direct researchers in industries, academic circles, and government offices in creative research activities beyond the organizational barriers, while making the most of the strong points of the life employment system, for the purpose of extracting and adopting these researchers superior concepts (Figure 3.3.10).

(b) The research methods are as follows:

i) Persons having eminent insights and leadership and a wide range of knowledge on research subjects are to be appointed as those responsible for general control. These responsible persons are to be invested with

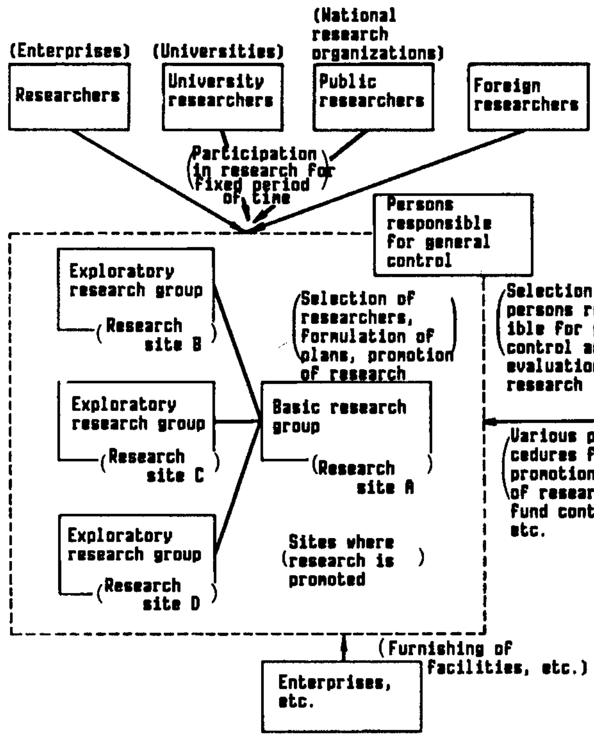


Figure 3.3.10. Outline of a System for Promotion of Creative Science and Technology

discretionary power concerning research management within certain limits, and research is to be comprehensively promoted under their direction.

ii) Persons of superior ability engaged in studies connected with research projects to be adopted will be invited from industries, academic circles, government offices, and foreign countries, and organized into research groups.

Existing private research laboratories, etc., are to be utilized for research facilities.

iii) Researchers are to take part in research projects by contract for a certain period of time (for 5 years, for example) upon coordinating with the research organizations to which they belong, while being enrolled in the organizations or on the premise of returning to them. The research groups are to be dissolved upon the completion of research.

iv) In pursing research projects, flexible management is to be conducted by exploiting the researchers' originality in such a way as to be able to make a flexible change of their research targets during the research, e.g., positively pursing a new development of an unexpected discovery or invention.

v) Consideration is given to incentives in order to stimulate the desire to participate of superior researchers in industries, academic circles, and government offices, and particularly of those in private enterprises. Industrial ownership, etc., arising during research is to be jointly obtained by the Research Development Corporation of Japan and the inventors, and it can be transferred from the inventors to the party originally dispatching them after termination of the research period.

(iii) Outlines of research projects

(a) Four research projects (finished in September 1986) were started in October 1981, one in October 1982, October 1983, and October 1984, respectively, two in October 1985, and three in October 1986. Outlines of these research projects are given in Table 3.3.11.

(b) Each research project consists of three to five research groups, with about 20 researchers assigned to each project. The research period is currently limited to 5 years.

Table 3.3.11. Outline of Research Projects Under Creative Science and Technology Promotion System (FY 1986) (¥1 million)

Research project	Research group/ Place of research	Places dispatching researchers	Outline	Budget
Hayashi superfine particle project	Basic physical properties Meijyo University (Nagoya) Physical application Stanley Electric (Tsukuba) Biological and chemical application Stanley Electric (Tsukuba) Methods of formation Japan Vacuum (Chiba)	Vacuum Metallurgical Corp., Stanley Electric, Sony, Japan Vacuum, Nippon Denso, Hitachi, Fuji Photo Film, Mitsui Toatsu Chemicals, Arizona State University, Yale University, Cornell University, Manitoba University, Osaka University, Kansei Gakuin University, Tokyo Institute of Technology, Nagoya University, Nihon University, and Hokkaido University	Noting attention paid the fact that fine metal and metal compound particles smaller than 1/10 μm have natures different from those of bulky materials, possibilities of using them for industrial materials are to be sought, while closely examining their physical properties.	181
Masumoto special structural substance project	Basic physical properties Electromagnetic Research Lab (Sendai)	Osaka Cement, Otsuka Chemical, Shimazu Seisakusho, Sony, Tohoku Metal Industries, Toda	Diverse research is to be pursued from the directions of physical properties, metal	219

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places dispatching researchers	Outline	Budget
	Amorphous composite materials Otsuka Chemical Co. (Tokushima) Amorphous thin film materials Gakushin University (Tokyo) Special ceramic materials Furukawa Electric (Tokyo) Interlayer compounds Electromagnetic Research Lab (Sendai)	Industrial, Nippon Denka, Furukawa Electric, Mitsui Mining and Smelting, Riken, Electromagnetic Research Lab., Gakushin University, and the United States	engineering, electronic engineering, etc., to seek a clue to new materials and elements from the structures and natures of amorphous metals, ceramics, and interlayer compounds, which are not found in ordinary crystals.	
Ogata fine polymer project	Molecular design Sophia University (Tokyo) Materials with selective functions Mitsubishi Chemical Industries (Yokohama) Organic electronic materials Matsushita Research Institute (Kawasaki)	Idemitsu Kosan, Kao Soap, Sumitomo Chemical, Dai Nippon Printing, Toyo Ink Manufacturing, Toray Research, Toppan Printing, Nippon Synthetic Rubber, Matsushita Research Institute, Mitsubishi Chemical Industries, Sophia University, and the United States	Methods for synthesizing polymers with selective functions, semiconductor properties, etc., are to be pursued with a view to making free designs for high polymer functions, with fixed functions and research to explore synthesis techniques and ultimate molecular weight.	131
Nishizawa perfect crystal project	Basic structures Semiconductor researchers (Sendai) Superhigh-speed devices Mitsubishi Electric (Itami) Methods to form perfect crystals Mitsubishi Metal Mining (Omiya)	Oki Electric, Olympus, Sanyo Electric, Seiko Electronics, Hamamatsu Photonics, Mitsubishi Metal Mining, Mitsubishi Electric Semiconductor Research Lab., Sanyo Electric Hanken,	Possibilities of creating such superhigh performance elements as high-power and optical elements, which should follow the present semiconductor elements, are to be probed by	177

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places to dispatching researchers	Outline	Budget
	Optically functional devices Hamamatsu Photonics (Hamamatsu)	Tohoku University, Tokyo University, Osaka University Taiwan, Hungary	introducing new element structures using electrostatic induction effects, while taking the perfect-crystal technology and the theory on electrostatic induction control as the central propositions and pursuing a perfect-crystal growth technology.	
Mizuno bioholonics project	Basic design Nissho Building (Tokyo) Control Teikyo University (Sagamiko) Structure Nissho Building (Tokyo)	Nihon Shoji, Toyo Jozo, Sanyo Electric, Tokyo University, Kyoto University, Saitama University, Hiroshima University, Teikyo University, Meiji Pharmaceutical College, East Germany, Eisai, Terumo, Kanegafuchi Chemical Industry, Kyowa Hakko Kogyo, Hitachi, Konishiroku Sumitomo Pharmaceutical, Mitsubishi Gas	Noting the cooperative relationships among the entire system of each living thing, consisting of cells, tissues, organs, etc., and individual constituents of the system, artificial elements (holons) that can cooperate with one another and models of self-organization by arranging elements are to be produced, and methods of controlling them are to be studied. Autonomy of living things is to be utilized by medicine and its development to engineering uses is to be explored.	340

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places to dispatching researchers	Outline	Budget
Hirokoshi special environmental microorganism project	Basic properties Riken Komagome (Tokyo) Substrate metabolism Riken Komagome (Tokyo) Granting of tolerance Hamamatsu Photonics (Hamamatsu)	Kumiai Kagaku, Oji Paper, Toray, Meiji Seika, Morinaga Milk Industry, Kyupi, Godo Shusei, Mitsubishi Electric, Idemitsu Kosan, Suntory, Zeria Shinyaku, Fujisawa Pharmaceutical, Japan Gasoline, Nippon Food Processing, Marubishi Bioengineering, Tokyo University, Tsukuba University, Tohoku University, Nihon University, the United States, Britain, West Germany, New Zealand, China	Noting the microorganisms growing in specific environments, including alkalinity, acidity and high temperatures, the possibilities of producing useful substances such as new antibiotics and increasing the efficiency of conventional substance production processes are to be explored by determining the tolerance mechanism of these microorganisms and granting tolerance to ordinary microorganisms.	355
Yoshida nano structure project	Basic analyses Tsukuba Research Consortium Measurements and and control Tsukuba Research Consortium Processing Nippon Kogaku, Oi, Tokyo	Asashi Seisakusho, Japan Steel Corp., Nippon Kogaku, Intel, Yasukawa Electric Manufacing, Seiko Electronics, Nippon Koku Denshi, Waseda University, Hiroshima University	Noting the physical actions and mechanical natures of substances in the nanometer sphere, analyses of these actions and natures are to be carried out and elemental techniques on their mechanical structures are to be explored through research on new measuring and processing methods.	309

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places to dispatching researchers	Outline	Budget
Kuroda solid-state surface project	Basic properties Tsukuba Research Consortium (Tsukuba) Surface reaction Tsukuba Research Consortium (Tsukuba) Functional structure Toray Research (Otsu)	Japan Steel Corp., Rigaku Electric, Sanyo Electric, Toppan Printing, Chemical Research Institute, Mitsubishi Metal Mining, Kao Soap, Mitsubishi Chemical Industries, Toray Research, Toray, Hitachi, Mitsui Toatsu Chemicals, Tokyo University, Molecular Science Institute, Hokkaido University, and the United States	Research is to be conducted on the structure, physical properties and reactivity of modified solid-state surfaces through pursuit of a method to modify solid-state surfaces whose identity has been known, by using the scientific reactions arising on these surfaces, and methods for synthesis of new substance systems designed on two- and three-dimensional bases are to be probed through use of a surface modification method acquired through this research.	327
Goto magnetic flux quantum project	Basic properties Hitachi (Tokyo) Environmental control Japan Vacuum (Chigasaki) Structural methods Mitsui Shipbuilding and Engineering (Tokyo)	Hitachi, (Alpac Cryo), Mitsui Shipbuilding and Engineering, the Netherlands, Japan Vacuum, Tokyo University	Noting the fact that a magnetic flux quantum acts at an extremely high speed and with low energy, electric and magnetic phenomena accompanying the generation and transmission of this flux quantum are to be explained, and a method of controlling the magnetic flux	98

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places to dispatching researchers	Outline	Budget
			quantum and ways of applying it to information processing, measurements, etc., are to be explored on the basis of this knowledge.	
Takaraya super-molecule soft structure project	Basic analyses Stanley Electric (Tsukuba) Reconfiguration Production Development Scientific Research Institute (foundation in Kyoto) Functional system Stanley Electric (Tsukuba)	Osaka University, Nagoya University, Toyoda Central Research Laboratory, Yasukawa Electric Manufacturing, Nippon Mining, Matsushita Electric Industry	Noting the soft structure of super molecules which control their functions in conformity with environmental conditions, the operational principles of such mechanisms as low-level energy conversion and the transport of specific substances are to be investigated, and a clue toward constructing molecular systems having such advanced functions as motion and memory will be sought.	100
Inaba biophoton project	Measuring techniques Electromagnetic Research Institute (Sendai) Biochemical information Electromagnetic Research Institute (Sendai) Information processing Electromagnetic	Tohoku University, the United States, Nippon Bunko, Tohoku Electronics, Advantest	A method is to explored for precisely measuring extremely weak lights (biophotons) among the luminous phenomena closely connected with life phenomena, and the possibilities of cultivating new measuring	100

[continued]

[Continuation of Table 3.3.11]

Research project	Research group/ Place of research	Places to dispatching researchers	Outline	Budget
	Research Institute (Sendai)		techniques of living things are to be sought based on information obtained by this method.	

(3) System for Research and Development of Basic Technologies for Industries in the Next Generation

(i) Circumstances leading to the system

Japanese technologies are currently at the average level among the advanced industrial nations. In the technological field including iron and steel, automobile and electrical machinery and equipment, some items have reached the top level internationally. However, this is a result of Japan's having introduced technologies from advanced nations in a positive way since the end of World War II and having continued to improve them in order to iron out its technological differences from the advanced industrial nations of Europe and America. Therefore, it can be said that Japan is still lagging behind these advanced nations in the aspect of creative research and development in developing its own innovative technological.

In order for Japan to overcome its weakness arising from poor resources, it is necessary to promote research on and development of basic technologies, particularly those which are indispensable for the establishment of industries in the next generation including aeronautics, space, information processing, new energies, and the bioindustry, and to raise, without delay, the level of its basic technologies which are said to be lagging behind those of advanced Western nations. However, the development of such basic technologies requires a huge amount of funds and a long period of time, and also involves heavy risks, although, on the other hand, it has big multiplier effects and it is a strong requirement from the standpoint of the national economy. In FY 1981, therefore, the Ministry of International Trade and Industry established a "system for the research and development of basic technologies for industries in the next generation" to utilize the potential of the private sector as well in a positive way, under a systematic, efficient research and development formula.

With the coming of the sixth anniversary of the establishment of this system, research and development under a second-term plan are being pursued in regard to most themes, in addition to initiating research and development on bioelements in FY 1986, and satisfactory results are being achieved steadily.

(ii) Outline of the system

In the three fields of new materials, biotechnology and new functional elements, the ministry is scheduled to select themes proven theoretically and experimentally to hold possibilities of putting innovative industrial technologies to practical use (stage of seed leaves), and conduct research and development on these themes until prospects are obtained for putting such industrial technologies to practical use (stage of young plants). Also, in order to proceed with research and development efficiently, the ministry is scheduled to adopt a parallel development formula to carry out simultaneously multiple research and development formulas, and also to select an appropriate formula by dividing a long-term (about 10 years) total plan into three stages or so every several years, setting certain targets at the respective stages (stage-classified target setting formula) and evaluating the situation and results of the research and development at each stage.

This system is to be pursued with the cooperation of three parties--industries, academic circles, and the government (national experimental and research organizations). Research and development are to be commissioned to private enterprises, etc., as well in order to utilize the potential of industries, and national experimental and research organizations are also to carry out research and development by exploiting their actual results. In addition, cooperation is being sought from universities, etc., according to the research content.

(iii) Outline of research-development projects

Outlines of 13 themes for which research and development are being pursued under this system and the amounts of budgetary appropriations for FY 1986 are shown in Table 3.3.12.

Table 3.3.12. Outline of Research and Development Themes Under the System for Research and Development on Basic Technologies for Industries in the Next Generation, and the Amounts of Budgetary Appropriations for FY 1986

Research-Development themes	Outline
(New Materials) (¥3.59 billion)	
1. Fine ceramics	Development of structural materials of high temperature and high reliability, having such characteristics as great strength and high corrosion resistance, high precision, and high wear and abrasion resistance, and establishment of techniques for application thereof to ceramic turbines for the creation of coal gas.

[continued]

[Continuation of Table 3.3.12]

Research-Development themes	Outline
	Through the application of these structural materials to heat engines, such as turbines, to produce coal gas, energy is expected to be greatly economized on through reduction in weight and improvement in thermal efficiency. They are also expected to be applied to advanced industrial fields including nuclear energy, aeronautics, and space.
2. Materials for high-efficiency highpolymer separation film	High-efficiency liquid separation films and gas separation films are to be developed to enable the separation, concentration, and refining of materials which consume a large amount of energy under the conventional separation methods and those which are difficult to separate. Through application of these materials to various separation and refining processes, they can be expected to aid in economizing on energy to a great extent, making the chemical industry clean and free from environmental pollution and creating compact chemical plants, and also for the recovery of materials which are difficult to separate.
3. Conductive highpolymer materials	Development of practical highpolymer materials of highly conductive materials (room temperature: 10^6S/cm (S: siemens = $1/\Omega$)) which are safe and easy to process, and also of materials with new functions, not possessed by metals, as electrical and electronic materials. These materials can be expected to help in economizing on resources and producing compact electric wire-supporting structures (indispensable for such purposes as developing sea-bottom resources) by substituting for copper or aluminum electric wire, and in producing organic superconducting materials.
4. Highly crystalline highpolyer materials	Development of highpolymer materials which are highly crystalline and whose modulus of flexural elasticity as a representative dynamic property is about 100 GPa (giga pascal = 10,000 kgf/mm^2).

[continued]

[Continuation of Table 3.3.12]

Research-Development themes	Outline
	They are expected to aid in economizing on resources by substituting for such structural materials as aluminum and iron, and in producing materials which are very strong and superior in electric insulation, processing characteristics, etc.
5. High-performance crystal control alloys	Ultra-heatproof alloys, heatproof strong alloys and lightweight and strong alloys are to be developed for such technical demands as producing single-crystal alloys.
	Through reduction in weight and increased strength and thermal resistance, they are expected to greatly improve the performance of machinery and equipment and economize on energy in advanced technological fields, including nuclear energy, aeronautics, space and new substitute energies.
6. Composite materials	Resin composite materials (FRP) and metallic composite materials (FRM) are to be developed as lightweight, very strong, and highly tolerant structural materials.
	When used as structural materials for aircraft and spacecraft, it can be expected that they will help greatly economize on energy by reducing the weight of transportation facilities, including automobiles, in addition to rapidly improving the performance of aircraft, etc.
7. Photoreactive materials	Development of photoreactive materials that can be used for superhigh-density information records, etc., through controlling the structures of molecules and the state of their assemblage by the action of lights.
	They will help accelerate the development of ultralarge capacity memory devices for ultralarge computers, ultrasmall disks for business and home use, etc. They are also expected to make contributions to high resolution indication techniques and high-speed optical operation and processing techniques using optical switches.

[continued]

[Continuation of Table 3.3.12]

Research-Development themes	Outline
(Biotechnology) (¥1.222 billion) 1. Bioreactors	Development of bioreactors capable of greatly economizing on resources and energy in reactions consuming large amounts of energy (oxidation and synthesis reactions, for example) among major reactions in chemical industries. By using them during reactions in chemical industries, it can be expected that they will contribute toward energy-saving chemical industries under normal temperature and pressure without causing environmental pollution.
2. Technology for cultivation of large amounts of cells	Development of substitutes for cattle embryo serums, indispensable for the cultivation of animal cells, and also basic techniques to carry out high-density cultivation of animal cells by using these substitutes. These are included among the basic techniques in biotechnology, and are expected to make it possible to achieve a safe, plentiful supply of fine chemical products, the industrial production of which has, so far, been impossible.
3. Techniques for the use of recombined DNA	Development of technology for creating new microorganisms able to produce substances which can be used for industrial purposes by a DNA recombination process using hosts--vector-system hosts or very safe hosts to be developed for the first time--approved by guidelines for experiments in recombined DNA. This is one of the basic techniques of biotechnology, and can be expected to serve such purposes as upgrading chemical industry processes and economizing on resources and energy through the application of useful microorganisms created by this technique to chemical industries.

[continued]

[Continuation of Table 3.3.12]

Research-Development themes	Outline
(New functional elements) (¥1.545 billion)	
1. Superlattice elements	Development of superlattice functional elements intermittently stacked with many layers of very thin film crystals of different materials, and of superstructural lattice elements having electrodes controlling the moves of electrons in semiconductor thin film crystals below several thousand Å. These elements are expected to make it possible to effect superhigh-speed calculations beyond the limits of conventional elements ordinarily functioning at normal temperatures, and superhigh-frequency oscillation and amplification.
2. Three-dimensional circuit elements	Development of integrated high-density elements where logic, memory, and other functions are integrated with high density by forming a laminate structure, and multifunctional integrated elements where many composite functions are integrated, including signal conversion functions, sensor functions, etc. These elements are expected to help in reducing the size of computers and increasing their speed, and also to make it possible to carry out sensory information processing involving sight with one IC element, for example, by making one element multifunctional (measurement, calculation, memory, display, etc.)
Bioelements (new theme)	Excellent information processing functions possessed by living things, such as learning and memory, are to be explained on an engineering basis with a view to creating new functional elements. For this purpose, molecule organizing techniques to realize functions possessed by living things, including their potentials, molecular recognition and self-organization, are to be developed simultaneously. It is expected that bioelements, challenging the integration limits of semiconductors, will be applied to information processing equipment capable of efficiently resolving problems which cannot be dealt with by the present computers.

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END

10

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